NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No 7.

MERCURY, OR "QUICKSILVER,"

IN

NEW SOUTH WALES,

WITH

Notes on its Occurrence in other Colonies and Countries.

BY

J. E. CARNE, F.G.S.,

GEOLOGICAL SURVEYOR.

1900.

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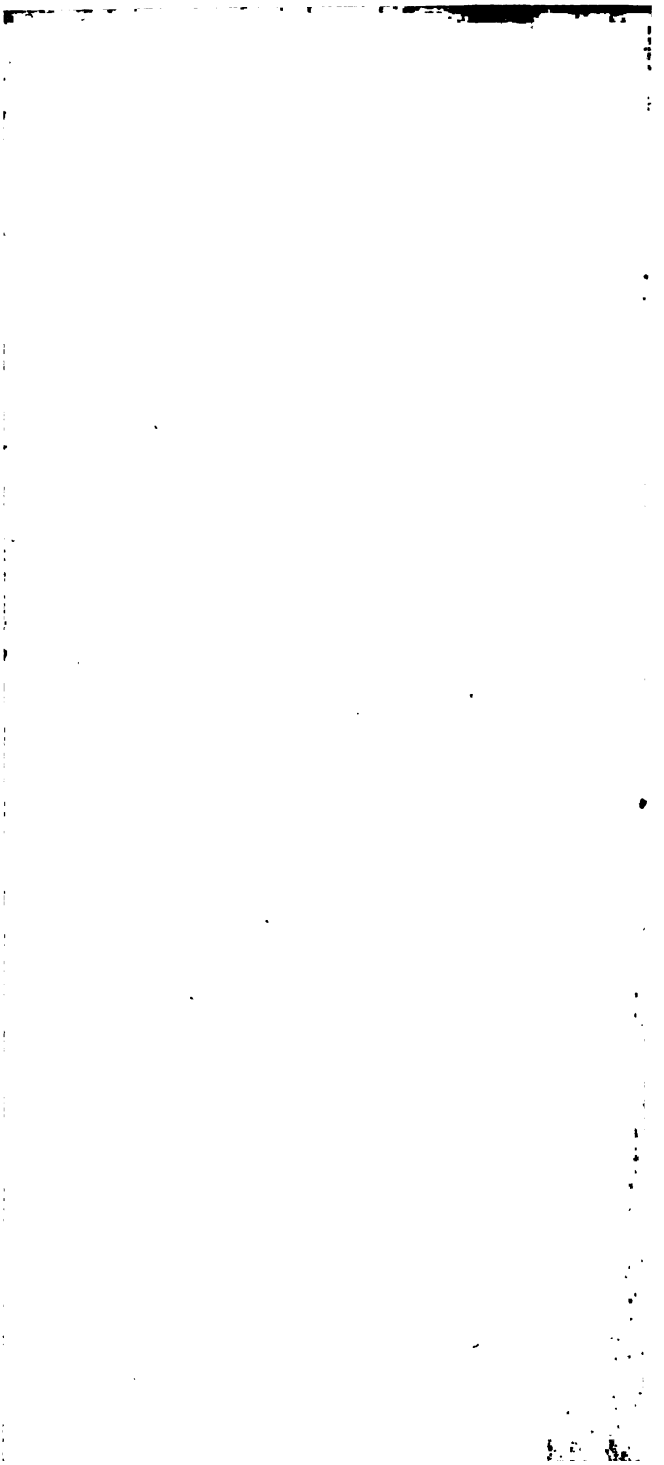

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Geological Survey Branch,
Department of Mines and Agriculture,
2 May, 1900.

Sir,

I have the honor to transmit for publication, Report No. 7 of the Mineral Resources Series, on "Mercury, or Quicksilver, in New South Wales, with Notes on its occurrence in other Colonies and Countries," by Mr. J. E. Carne, F.G.S., Geological Surveyor.

Ores of mercury have not hitherto been profitably worked in New South Wales, although deposits of cinnabar have for some years been known to exist in several districts. In view of the very large quantity of mercury which is annually used in this Colony in connection with the gold-mining industry, it would be a very great advantage if the metal could be produced locally. It is therefore of importance that careful descriptions of the known deposits of cinnabar should be published by the Department, and it is to be hoped that where the attention of mining men has been thus directed to the subject, efforts will be made, not only to work the deposits which are already known to exist, but also to prospect for the mineral in other localities.

I have the honor to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines.

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INTRODUCTION.

PRIOR to the practical application of the valuable amalgamating property of mercury in silver metallurgy by a Mexican miner in 1557, the use of the metal, though of ancient date, was restricted chiefly to the very limited demands of the fine arts; the brilliant pigment "vermilion" being prepared from the natural or artificially produced sulphide of mercury.

The Mexican discovery rapidly augmented the demand for quicksilver for the extraction of silver from its ores, and correspondingly increased its output. The extension of amalgamation to gold-mining and milling at a comparatively recent date, however, gave the principal impetus to the industry, and has governed all subsequent demand and supply.

The powerful affinity of mercury or quicksilver for gold, and the ease and efficiency of its application as a collector and saver, render it practically indispensable to the gold-mining industry. Its usefulness and comparative rarity—for mercury occurs in relatively few places in workable quantities—maintain for it continuous demand and value, though the reported control of a powerful combine or "ring" may, and probably does, frequently unduly influence the latter. Demand and supply, therefore, may not always balance fairly at ruling market rates, which are subject to considerable fluctuation.

The capricious occurrence and comparative poverty of mercury ores, combined with cost and loss in reduction, in the majority of instances narrow the margin of profit to extremely fine lines. Becker, in 1888, estimated the cost of production at 90 per cent. of the average price.*

Hence in this, as in all other metalliferous mining, the lowest grade deposits demand the maximum of knowledge and experience. Rich deposits can sustain experimental or undue working loss, the avoidance of which in treatment of lower grades represents the only possible margin of profit.

It is imperative, therefore, that the possible inception of the mercury industry in Australasia should be safeguarded in this direction. Haphazard methods of management must give way to wiser counsels in the institution of an entirely new and difficult enterprise in these regions.

In the early days of gold discovery in California and Australia, the sudden excessive demands for quicksilver, operating on a slender market, forced values to an abnormal height (over £23 per flask of 76½ lb. being realised according to Egleston),† which decreased gradually in direct ratio with

* Geol. of Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, 1888, p. 1.

† Metallurgy of Silver, Antimony, and Mercury in the United States, 1890; by T. Egleston, vol. ii, p. 799.

increasing supply and waning gold production until £9 per flask was reached in 1866. In 1870 a sudden rise to £29 per flask took place, according to the same authority; after which it fell steadily to about £5 per flask in 1883, since when it has fluctuated between £5 10s. and £9 12s. 6d. per flask, the latter being the rate now ruling. †

The present average market value appears likely to be maintained unless phenomenal discoveries ensue, for, notwithstanding the rapid advance in metallurgical and electro-metallurgical science, no substitute or process is foreshadowed to completely contest the monopoly of this valuable mobile metal, or dispute its economic utility and efficiency as a gold saver when the precious metal is in a condition open to attack.

Chlorination and cyanidation gold-recovery processes are independent of mercury in their especial spheres; yet these, from their comparatively limited application, are subordinate and subsidiary to ordinary amalgamation.

The cost of chlorination restricts it with rare exceptions, such as Mount Morgan in Queensland, to treatment of concentrates after amalgamation, in which gold is mechanically cloaked by sulphides of baser metals. Extraordinary fineness and a filmy coating of iron oxide prevented perfect contact with the Mount Morgan gold.

Cyanidation is almost equally as rigidly confined to tailings—or exceptional ores—containing gold in so fine a state of division as to render specific gravity inoperative and contact impossible during water transport over amalgam plates.

The importance, therefore, of workable deposits of mercury in a gold-producing country cannot be easily over-estimated. Unfortunately, Australasia has not yet been able to add it to her list of profitable mineral products, though in New South Wales, Victoria, Queensland, and New Zealand the principal and only workable ore, the sulphide cinnabar and its varieties, has been found in more or less hopeful quantities (associated, in some instances, with the native metal), from which small quantities of mercury have been locally retorted.*

The present number of "Mineral Resources" is a statement of the occurrence of mercury in New South Wales, and the progress of its mining developments to date, supplemented by notes on discoveries in the neighbouring Colonies, and on the principal sources of the World's supply, the object being to stimulate interest and promote research, in the hope of further and more important discoveries within Australasian territories.

* Mr. R. M. Johnston, F.L.S., in the Tasmanian Official Record, 1892, p. 126, mentions the selenite of mercury (*Onofrite*), but the locality is not given. In the same work for 1893, p. 10, the occurrence of mercury with other ores in Silurian rocks is recorded. The locality is, however, again omitted.

† Mining Journal, 1900, lxx, No. 3266, p. 227.

MERCURY, OR "QUICKSILVER."

Physical Characteristics.

A SILVER-WHITE lustrous metal, fluid at ordinary temperature. Specific gravity 13·59 (Regnault). Solidifies at about 39 to 40° C. Vapourises at 360° C. Vapour density, 6·7 to 7·03. For complete volatilization, a low red heat 500 to 600° C. is required (Schnabel and Louis).

Alloys of Mercury.

Mercury amalgamates readily with gold, silver, zinc, tin, cadmium, lead, and bismuth; with copper easily when finely divided, but with difficulty in the massive state; arsenic, antimony, and platinum amalgamate with difficulty; iron, nickel, and cobalt not at all directly.*

Chief Uses.

Amalgamation of gold and silver; preparation of vermilion; in medicine; barometers, thermometers, mirrors, &c.

The great density of mercury, and its regular expansion and contraction by increase or diminution of temperature, render it most suitable for filling barometers and thermometer tubes.

Ores of Mercury.

Cinnabar (HgS)—Mercury Sulphide. Specific gravity, 8·99; hardness, 2 to 2·5; contains 86·2 per cent. of mercury. The most important ore of mercury.

Varieties.

Metacinnabarite.—Black variety, non-crystalline. Lower specific gravity than cinnabar.

Hepatic Cinnabar.—Cinnabar mixed with bituminous matter, which gives it a red to black colour.

A mixture of cinnabar with idrialite (C_3H_2), occurs at Idria.

Coralline Ore.—A mixture of cinnabar, bituminous matters, and about 60 per cent. of calcium phosphate.

Ammiolite.—An earthy powder, colour deep red, regarded as an antimonate of copper mixed with cinnabar.

Onofrite.—A sulpho-selenite of mercury occurring at San Onofre, in Mexico.

Tiemannite.—Mercuric selenide.

Coccinite.—Iodide of mercury; Mexico.

Livingstonite.—A sulphide of antimony containing mercury.

Mercurial Fahlore, or *Tetrahedrite*, sometimes contains up to 18 per cent. of mercury (Schnabel and Louis).

Zinc-blende occasionally contains small quantities of mercury.

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* Handbook of Metallurgy, Schnabel and Louis, 1898, ii, p. 254.

Principal Sources of Supply.

Europe and America.

The most important mercury deposits in Europe are Almaden in Spain Idria in Carniola (Austria-Hungary), and Nikitowka in Southern Russia.

The following brief descriptive notes are extracted from the Handbook of Metallurgy*:—

"At Almaden, cinnabar occurs with native mercury in an area 10 miles by 6 miles in Silurian and Devonian strata, consisting of slates, quartzites, sandstones, and small quantities of limestone, forming three almost tabular deposits about 600 feet in length, and 12 to 25 feet wide. In these the mercury ore occurs both in masses and disseminated. The grade varies from 0·75 to 25 per cent., and is said to average about 8 or 9 per cent.

"These deposits were known as early as 300 B.C., and still remain the most important in Europe."

According to Becker† they are reported to increase in richness with depth.

The Idrian deposits occur partly in the nature of a stockwork, and partly as contact veins between dolomite and limestone of Triassic age. The ore averages from 0·5 to 0·8 per cent. These deposits were known in 1490, and rank next in importance to those of Almaden, and like them are reported also to increase in richness with depth. (Schnabel and Louis, *ibid*, p. 258.)

At Nikitowka, in Southern Russia, cinnabar occurs impregnating sandstone of Carboniferous age, having a thickness of 46 feet. The average grade is stated to be 0·6 per cent. These deposits rank next in importance to those of Almaden and Idria in Europe.

The most important mercury deposits in North America—the New Almaden, New Idria, Napa Consolidated, Etna Consolidated, Altoona, and Great Eastern, —occur in California. At one time their output exceeded that of Almaden in Spain, but, unlike the latter, the deposits decreased in value with depth.

The North American mercury deposits are stated by Schnabel and Louis to occur in a "zone of slates of the Cretaceous and Tertiary periods, consisting of talcose, micaceous, clay and siliceous slates, serpentines, sandstones, limestones, and dolomites, penetrated by numerous outbursts."

"This zone of slates is more or less strongly impregnated with cinnabar in various places, at some of which, especially where serpentine and sandstone are in contact, the proportion of mercury is a very high one, amounting to as much as 35 per cent. The ore occurs both as contact deposits and also disseminated in serpentine and sandstone. At various places the cinnabar is accompanied by pyrites and bituminous substances; at others it occurs impregnating chalcedony, which may then contain as much as 3 to 10 per cent. of mercury."

The deposits at Sulphur Bank in California, and Steamboat Springs in Nevada, are especially interesting on account of their association with still active geyser action. Cinnabar here accompanies sulphur, which at Sulphur Bank was first mined. The average grade is reported as 1·75 per cent. of mercury.

Becker states‡ that "rocks enclosing quicksilver deposits are of very diverse ages, ranging all the way from Archæan granites and schists to recent strata and lavas. The lithological variety of the enclosing rocks is equally great, including limestones, sandstones, and shales, many kinds of metamorphic strata, and massive rocks of acid, neutral, and basic types."

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* Schnabel and Louis, 1893, ii, pp. 256, 257.
† Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, 1888, p. 4.
‡ *Ibid.*, 452.

He further states that quicksilver deposits occur along the great axes of disturbance of the world; also that cinnabar occurs in "true, simple, fissures and veins, in impregnations, and stockworks"*

"The facts recorded point to the supposition that most of the quicksilver deposits, if not all of them, have been formed in a similar manner. They have all been deposited from solution, for the gangue minerals could have been formed in no other way.

"The gangue minerals are few in number and substantially the same in all deposits." . . . "They are crystalline silica, opal, calcite, and dolomite."

Cinnabar is being deposited from thermal springs at high temperatures at Pozzuoli, in Italy, Steamboat Springs, Nevada, and Lake Omaphere, New Zealand, and there is reason for believing that similar conditions prevailed in all deposits.

R. B. Symington, writing of the Californian deposits, states :—"Generally the veins are mineralizations, along faults occurring near the contact of metamorphic and unaltered rock. A variety of serpentine, locally called 'quicksilver rock' is the usual metamorphic rock; while sandstone and shale constitute the unaltered strata."

"Occasionally the ferruginous shales are interlaminated with bands of jasper which often has a bold outcrop, and, looking like cinnabar, is sometimes mistaken for the latter, but the real veins seldom show a bold outcrop." [Large boulders of red jasper in the Cudgegong cinnabar drift have been similarly mistaken.—J.E.C.]

"When a porous rock like sandstone forms the wall of a vein, it is often impregnated with cinnabar for a considerable distance from the fissure, and the true vein matter may be comparatively barren; but if clay, or any impervious rock, forms the wall, no ore will be found beyond that line."‡ The writer recommended crosscutting in consequence of the above features. He further stated that formerly it was the custom to search only for higher grade ore; now everything over 0·5 per cent., or ½ per cent., is worked. More than once the waste dumps have been turned over with profit.

AVERAGE WORKING YIELDS OF SOME OF THE PRINCIPAL MERCURY MINES.

	Mine.	Tons of Ore smelted.	Average Yield.	Flasks of Mercury Produced in 1898.	Receipt per Flask.	Cost per Flask.	Remarks.
			%		$	$	
California.	Napa Consolidated	32,489	0·8	6,850	35·89	21·33	Total production of United States in 1898 = 30,498 flasks.
	New Idria	18,627	1·03	5,000	35·86	17·48	
	Etna Consolidated	18,394	0·72	3,450	36·03	23·55	
	New Almaden ..	....	....	5,875	....	....	Worked to a depth of over 2,000 ft.
	Altoona	....	....	4,032	....	....	
	Great Eastern ..	....	....	1,704	....	....	
	Redington	....	....	990	....	....	
Italy.	Almaden, Spain ..	....	8·0	46,211*	....	....	* Produced in 1898.
	Idria, Austria ..	....	0·8	.....	....	....	
	Nikitooka, Russia†	....	1·0	10,104*	....	....	* 22,122 poods in 1898.
	Siele ..	....	1·2	.....	....	....	Average metallic contents of ores smelted at these mines, according to Vincente Spirek (*Mineral Industry*, vi, 1897, p. 568); an increasing proportion of low-grade ores is being worked in Italy.
	Cornacchino	....	0·6	.....	....	....	
	Montebuona	....	0·4	.....	....	....	
	California, U.S. ..	....	1·3	.....	....	....	

* *Op. cit.*, pp. 388, 453.

‡ Mineral Industry, 1898, vii, p. 592.

† Russian yields (*Mineral Industry*, vi, p. 567)—1887, 1 per cent.; 1888, 0·76 per cent.; 1889, 0·51 per cent.; 1890, 0·73 per cent.; 1891, 0·8 per cent.; 1892, 0·65 per cent.; 1893, 0·46 per cent.; 1894, 0·46 per cent.; 1895, 0·69 per cent.; 1896, 0·71 per cent.; 1897, 0·79 per cent.

World's Output of Mercury, 1898.

Spain	1,681	metric tons.
United States	1,058	,,
Austria	494	,,
Russia	362	,,
Mexico	353	,,
Italy	170	,,
Total	4,118	,,

Notes on the Metallurgy of Quicksilver.

C. Schnabel* states that two methods are used upon a large scale for the extraction of mercury—"the one depends upon the fact that at a high temperature the oxygen of the air combines with the sulphur of the mercuric sulphide, forming sulphur dioxide, whilst the mercury is set free," according to the following equation:—

$$(1)\ HgS + 2O = Hg + SO_2.$$

The other depends upon heating the mercuric sulphide with lime when the sulphur combines with the calcium, forming calcium sulphide and sulphate, whilst the mercury is liberated:—

$$(2)\ \begin{cases} 4HgS + CaO = 4Hg + 3CaS + CaSO_4. \\ \text{Instead of lime iron may be employed—} \\ HgS + Fe = FeS + Hg. \end{cases}$$

In every case the above chemical reactions take place at temperatures higher than the boiling point of mercury; so that the latter is separated in the gaseous form, and has to be condensed.

"The first process is effected by heating cinnabar in the air; the second by heating with lime or iron, air being excluded.

"The mercury vapours in the first method are diluted with sulphur dioxide, nitrogen, and oxygen, and with the products of combustion if shaft or reverberatory furnaces be used."

In the second method the mercury vapours are in a concentrated condition.

The extraction of mercury by heating in air is regarded by authorities as the most suitable for economic and hygenic reasons. It may be carried out either in shaft, reverberatory, or muffle furnaces. When the two former are used, large quantities of ore can be treated with comparatively small consumption of fuel and labour. The process, however, is open to the objection already stated, of contamination of the mercury vapours with other elements, which interfere with condensation and occasion loss.

The extraction of mercury by heating with lime or iron must be performed in retorts. This process, however, requires the ore to be crushed, only small quantities can be treated, retorts last a comparatively short time, costs of fuel and labour are high, and workmen are affected by the fumes when the retorts

* Handbuch der Metallhüttenkunde. Eng. Trans. by H. Louis, 1896, ii, pp. 260, 261.

are emptied out; altogether unsuitable for poor ores on account of cost. The latter can only be treated on a large scale, for which furnaces and continuous roasters are alone adopted, according to Vincente Spirek * the inventor of one of the most successful improved furnaces.

According to Schnabel and Louis † the losses in the best furnaces and methods have been reduced from 50 to about 6 or 8 per cent of the amount of mercury in the ore.

Writing on the "Quicksilver Industry of Italy," Vincente Spirek ‡ states:—"In the metallurgy of quicksilver, one of the first principles is to adapt the furnace to the mine ore, and never attempt to adapt the latter to the furnace by means of wet concentration. It is when poor ores have to be treated that the greatest knowledge and experience in the selection of a proper furnace are required".

"The separation of the ore into grades of varying richness usually takes place in the mine itself, single rich pieces being won by spalling from the ordinary ore. The poorer ores are generally divided by screening into two classes—'coarse ore' of 35 mm. diameter, and 'fine ore', of less than 35 mm. diameter. The coarse ore is worked either by direct treatment in shaft furnaces by means of coke, coal, lignite, peat, or wood, or in so-called shaft reverberatories by means of gaseous fuel, produced in separate generators. The fine ore, which is sometimes again subdivided into medium, coarse, and fine, is worked in reverberatories *(Fortschauflungsofen)*, or continuous roasters *(Schüttofen)*. The rich ores are mixed with lime or iron, and treated by sublimation, either in continuous roasters or in muffle furnaces. The actual operations are therefore divided into the roasting method and the sublimation method.

"At the present time nearly all the works employ the roasting method, which consists in decomposing the cinnabar by means of an oxidation of its sulphur through the agency of atmospheric oxygen, and subsequent volatilization of the metallic quicksilver. It is thus evident that the theoretical extraction of the metal is a very simple one. In practical work, however, this is not found to be the case. The greatest practical difficulties encountered lie first in the excessive volatility of the metal, and secondly in its high specific gravity as a fluid, which greatly facilitates its penetration into the ground and into all the foundations, and lastly in a property which has so far received but little attention, and works exactly in an opposite direction to gravity, namely, the sickening of the quicksilver *(Quecksilberschaumbildung)* by fatty substances, which prevent the smallest metallic spheres from coalescing, and hold them as a fine film on the surface of the water, with which they are carried off, thus causing considerable losses."

As an instance of the leakage or penetration of mercury, Egleston § states that at the New Almaden Mine, in California, in 1863, 2,000 flasks (153,000 lb.) were taken from the ground under and near one of the furnaces, the mercury having penetrated 27 feet to bedrock.‖

Cinnabar mining is not in itself harmful, providing native mercury is not present in quantity. The precautionary measures advised against mercury poisoning in mining and smelting are cleanliness, open air, acid foods, and moderation in the use of alcohol.

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* Mineral Industry, 1897, vi, p. 569. † Handbook of Metallurgy, 1898, ii, p. 263.

‡ Min. Industry, 1897, vi, p. 569. § Metallurgy of Silver, Gold, and Mercury in U.S., ii, p. 814.

‖ A considerable leakage is reported to have taken place in connection with the limited smelting operations at the Ohaeawai Mines, New Zealand.

Mercury Localities in New South Wales.

Locality.	County.	Geological Formation.	Reference.	Page.
Bingara, Spring Creek, near	Murchison ..	Serpentine and clay slate.	T. W. E. David, Ann. Rep. Dept. Mines N. S. Wales for 1891, p. 234.	
Boorook, Clifton Silver Mine	Buller	Clay stone	Liversidge, Minerals of N. S. Wales, 1888, p. 52.....	
Broken Hill, Broken Hill Lode; Australian Broken Hill Consols Mine.	Yancowinna	With silver ores, in schists and hornblendic rocks.	H. Wood, Min. Products, 2nd Ed., 1887, p. 43.	
Carwell Creek, Cudgegong River.....	Roxburgh ...	Slates, sandstones, and limestones.	W. B. Clarke, Mines and Mineral Statistics N. S. Wales, 1875, p. 201.	
Corinda Creek, 5 miles westerly from Woolgoolga, North Coast.	Raleigh ? ...	In ferruginous quartz ...	Mr. A. McIntosh, Grafton	
Crow Mountain, near Barraba	Darling.....	In quartz Devonian	Assay Register, Nos. 98-3,127 and 98-3,449	
Cudgegong River, 6 miles below Rylstone.	Roxburgh...	Devonian sandstones, slates, and limestone.	W. B. Clarke, Mines and Mineral Statistics N. S. Wales, 1875, p. 201; W. B. Clarke, The Sydney Magazine of Science and Art, 1857, II, pp. 157-161, 170-173; C. S. Wilkinson, Ann. Rept. Dept. Mines N. S. Wales for 1884, p. 152.	
Dungog, Calton Hill	Durham.....	(?)	Liversidge, Minerals of N. S. Wales, 1888, p. 52	
Grove Creek, near Trunkey	Georgiana...	Alluvial Pleistocene	Cat. Sydney Exhibition, 1870, p. 445	
Horseshoe Bend, Clarence River	Drake.....	Felspathic rock	T. W. E. David, Prospecting Board Papers, 91-279	
Mookerawa	Westmoreland.	(Amalgam)	S. Stutchbury, Proceedings of Executive Council, 1851, vol. I.	
Moruya	Dampier ...	(?)	Liversidge, Minerals, N. S. Wales, 1888, p. 52	
Mudgee (Cudgegong ?).....	Phillip	Sandy schist	W. B. Clarke, Cat. Paris Exhibition, 1855; W. B. Clarke, The Sydney Magazine of Science and Art, 1857, II, pp. 157-161, 170-173.	
Ophir, near junction of Great Waterhole and Frederick's Valley Creek.	Bathurst ...	(Amalgam)	S. Stutchbury, Proceedings of Executive Council, 1851, vol. I.	
Scone, near	Brisbane ...	(?)	Mr. Dickson	
Sunny Corner	Roxburgh...	(?)	.....	
Yulgilbar, Clarence River	Drake.....	Hornblende granite, and diorite.	J. E. Carne, Ann. Rept. Dept. Mines for 1895, pp. 141-144; *ibid* for 1899.	
,, Spring Creek, Clarence River.	Drake	.....	....	

Occurrence of Mercury in New South Wales.

Historical.

The earliest official reference to mercury in New South Wales is contained in a letter from Mr. Stutchbury, Geological Surveyor, to the Colonial Secretary, from Orange, dated 9th June, 1851, in reply to an inquiry as to the presence of mercury in that district. Stutchbury was personally unaware of this, but added: "Report says it has been found near Capertee,"* a neighbouring locality, possibly confounded with Cudgegong, where, on the river of that name, about 5 miles west of Rylstone, it had been discovered, according to the Rev. W. B. Clarke, as early as 1841.†

Under date 18th October, 1851, Mr Stutchbury announced the presence of amalgamated gold, and the reported discovery of native mercury, in the Orange district, in the following terms:—"From indications of the presence of mercury exhibited at a spot near the junction of Frederick's Valley Creek, and the greater waterhole of Ophir, also on the Mookerawa Creek, where gold was shown to me in small quantities, externally whitened by an amalgam, and the parties assuring me they had seen globules of quicksilver in their cradles, and being perfectly aware that native mercury had been found in similar geological positions in Lord Rolles' Estate, High Torrington, North Devon, and near Berwick, in Scotland, and being fully impressed with the great importance of the metal in conjunction with gold-mining, I have diligently sought for it in all likely places. I have some doubt with respect to the first locality, supposing it might have escaped from some amalgamating machine; but at Mookerawa such could not have been the case, for no quicksilver had been used in the creek, and the repetition in precisely the same sort of clay—'decomposed clay slate,'—together with its identity with the North Devon case, assures me that native mercury does exist somewhere, and that possibly it may be found in quantity."

Subsequent extensive gold workings in these localities failed to reveal any further evidence of mercury deposits. Professor Liversidge's reference to Mookerawa Creek as a mercury locality is based on the above report.‡

Similar occurrences of globules of native mercury in the shallow gold-workings at the "Diamond Mines," about 6 miles easterly from Mittagong, and at Braidwood—observed by the Writer and Mr. J. B. Jaquet, Geological Surveyor—locally regarded as indigenous, are probably also attributable to escape from previously used amalgamating machines.

In 1855, the Rev. W. B. Clarke exhibited "Quicksilver in sandy schist from Mudgee."§

The same author, in 1857, in a paper on "Mercury Ores," read before the Philosophical Society of New South Wales, remarked—"In the year 1843–4, I procured from the neighbourhood of Mudgee a small sample of yellow soil, in which were interspersed several minute globules of quicksilver, which is a rare form of mercury in nature; but although the yellow colour agrees very well with a similar substance in which mercury is found in some parts of America, I have never satisfied myself as to the genuineness of the quicksilver. I have sometimes thought that it was nothing more than quicksilver spilt by the breakage of a barometer belonging to a previous explorer; for a similar accident happened to myself near Wianbene, on the head of the Shoalhaven, and someone who found the mercury on the ground imagined he had made a discovery."‖

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* Proceedings of the Executive Council, 1851, vol. i. † Mines and Mineral Statistics, N. S. Wales, 1875, p. 201.
‡ Minerals of New South Wales, 1888, p. 52. § Paris Exhibition, 1855.
‖ The Sydney Magazine of Science and Art, 1857, ii, pp. 157–161, 170–173.

A similar discovery was made some years ago on the Orara River Road, between Grafton and Nana Creek, so the Writer was informed, caused by breakage in transit of a bottle containing mercury.

The proved occurrence of mercury-ore—cinnabar—about 26 miles east of Mudgee, near Rylstone, lends colour to the authenticity of the find queried by Mr. Clarke. So far as can be ascertained, native mercury has not been found in association with the cinnabar at the above locality, though both Mr. Wilkinson, the late Government Geologist, and Mr. John Anthes—who is now working the deposit for gold—state that some of the drift gold is coated with amalgam. It is well for the prospector and observant explorer to preserve open minds—caution is as necessary in rejecting as in accepting reported discoveries, practical and geological research should confirm or refute.

Further reported discoveries are recorded and commented on by Mr. Clarke in the paper quoted. "When the Hon. E. Deas Thompson was Colonial Secretary, a gentleman produced to him, either in 1850 or 1851, a bottle of quicksilver, which he stated was collected from a waterhole at which he baited his horse, somewhere near Mount Wingen. In 1852 I examined that district, with which I was well acquainted many years before, for the especial purpose of tracing the locality alluded to, and I reported to the Government that I could not find any trace of such a discovery."

Cinnabar (?), reported from Swan Hill, Lower Murray River, prior to the date quoted, was proved by Mr. Clarke and others to be an artificial product, "corrosive sublimate" (mercuric chloride).

The practical discovery and opening of the Cudgegong cinnabar deposit occurred in 1869. The facts leading up to it were briefly related to the Writer by Mr. S. L. Bensusan, who formed the first company. Having for many years maintained a private laboratory for testing minerals free of cost to prospectors, numerous parcels passed through his hands. In 1869 a sample received from Peter Dickson, of Mudgee, proved to be cinnabar. The sender, however, discredited the determination. An agent of Mr. Bensusan's was therefore dispatched to Mudgee, with portion of the original sample, in search of the mineral *in situ*, which he succeeded in ascertaining was located in Portion 35, Parish Wells, County Roxburgh. After securing the land by purchase, Mr. Bensusan visited the site, and organised prospecting operations. A rich patch of cinnabar was shortly struck in a shallow shaft (14 feet) in drift. About 5 cwt. of the ore taken from it was subsequently retorted by the late Mr. Charles Watt, afterwards Government Analyst, in a Ure's ordinary gas retort, at Barcom Glen Ice Works, belonging to Messrs. Mort & Nicolle, near Paddington.

Shortly afterwards the Cudgegong Cinnabar Mining Company was formed, with a capital of £30,000 in £1 shares. The sum of £10,000 is reported to have been expended, chiefly in surface work. A bank of three Ure's retorts were erected at the mine, with a condensing chamber. In these a considerable amount of cinnabar-bearing drift was treated with lime, but the result was very disappointing, about six flasks of mercury only being produced. A system of concentration, by grinding in a form of arrastra, and washing in ordinary puddling machines, prepared the material for the retorts, the reduction equalling about 10 tons into 1. It appears, however, from a subsequent report by Mr. Bensusan to the Company, that under this system the loss was actually greater than the saving, the sludge carrying away an equal assay value of cinnabar as the reduced material contained. The Company, in consequence, did not long continue operations, and the undertaking was abandoned.

Wet concentration of cinnabar is at all times costly and wasteful. Vincent Spirek states that at Cornacchino mine, Monte Amiata, Italy, the tailings from wet concentration were worked over in modern furnaces, for a yield of 0·6 to 1 per cent. of mercury.*

Several reports were obtained by the Cudgegong Company on the nature and prospects of the deposit, extracts from which are of interest for comparison with later views.

In a letter by Mr. H. A. Thompson, dated October 12th, 1869, published by the Manager of the Company (Mr. W. H. Deloitte) in the *Sydney Morning Herald* shortly afterwards, it is stated that "the mine is situated on a flat at the foot of a range in this place, bounding the valley of the Cudgegong River. Here several shafts have been sunk through the alluvial deposits filling up the old tributary valley of the main river, only one of these shafts having reached the bedrock of the old valley, at a depth of 102 feet. The alluvium is of the usual character, consisting of beds of clay mixed with sand and rounded quartz. On the joints marking the separation of the different layers the cinnabar is found deposited, in many cases in grains of appreciable size, but for the most part in a state of fine powder. It is also found mixed throughout the deposits of sandy drift, and also in some of the clay beds."

. . . . . .

After alluding to reported rich finds of a misleading character, Mr. Thompson states: "A careful examination of the ground opened has, however, satisfied me that the rich patches of cinnabar there found were of limited extent, and that in taking out the alluvial ground such a large proportion of barren material must inevitably be mixed with the runs of ore as to leave no chance of such an operation being carried on profitably. . . . . ."

"It must be noted that an alluvial deposit of a hundred feet in thickness has been proved to be mixed with cinnabar throughout, and even close to the surface it is found with a modern deposit of alluvial gold."

"With so friable a material as cinnabar, a much larger proportion would be worn away and carried off by the water than has been left behind."

"It is hardly possible to suppose that the original deposit of cinnabar, whose denudation has supplied such a large amount of ore as indicated above, could be otherwise than of considerable size and richness, and the main object of the company should be to discover the position of the cinnabar vein by tracing up the alluvial deposit to its source."

The late Captain Josiah Holman, in a report dated 14th May, 1869, stated that some patches of rich ore had been struck in three shafts on an equal horizon of 40 to 50 feet; the general thickness of the richest bed averaging from 2 to 6 feet in clay formation, through which the cinnabar occurred either disseminated or in patches of higher grade. Above the horizon mentioned the mineral was more sparingly distributed right to the surface.

Carbonaceous shale was reported to have been struck at 91 feet in No. 3 shaft, which was regarded as a favourable indication, though no cinnabar was reported to occur in it.

In a later report by Mr. Bensusan, dated 23rd December, 1869, the interesting clay bed (false bottom of later observers) is mentioned in terms which the latest experience confirms:—"About 40 feet from the surface there exists a bed of clay of considerable thickness. I am informed that on the surface of this bed and in the drift above, all the cinnabar hitherto found has been obtained, but beneath it none has been met with."

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* Mineral Industry, 1897, p. 569.

Several shafts were mentioned in the report, but one only was in use, which had been sunk to bedrock at a depth of 116 feet. At 80 feet a drive was put in towards the hill "passing through the black clay slate" crossing the drive. This no doubt is identical with the "black carbonaceous shale" of Captain Holman's report. Evidently no trace of cinnabar was discovered in the bedrock as the utility of the work was questioned by the writer.

The report dealt exhaustively with the mining and metallurgical plant and the probable causes of the failure which then confronted the Company and shortly afterwards caused it to be wound up.

Reliable estimates of the value of the drift in cinnabar and gold are not possible, but judging from the results achieved in the past, and the desultory attempts since, mostly for gold, the deposit is certainly not payable. Mr. Wilkinson, at a later date, suggested hydraulic sluicing by pumping water from the river.

Samples of cinnabar from this mine, and from a more recent discovery in the Trunkey district (probably Grove Creek, near the Abercrombie Caves, where a little alluvial cinnabar has been found with gold), were exhibited at the Sydney Exhibition of 1870.*

In 1875 the Rev. W. B. Clarke wrote:—"Some years ago I reported on the occurrence of mercury in this Colony, but my expectation of the discovery of a lode of cinnabar has been disappointed. The cinnabar occurs on the Cudgegong in drift lumps and pebbles, and is probably the result of springs, as in California. In New Zealand, and in the neighbourhood of the Clark River, North Queensland, the same ore occurs in a similar way. About 1841 I received the first sample of quicksilver from the neighbourhood of the locality on Carwell Creek, on the Cudgegong, where the cinnabar is found."† Carwell Creek junctions with the Cudgegong River immediately below the cinnabar deposit. It seems more than probable that Mr. Clarke's previous reference to quicksilver in sandy schist from Mudgee, and his later reference to Carwell Creek, refer to the same discovery.

In 1884 the late Government Geologist, Mr. C. S. Wilkinson, visited the site, and furnished the following description of the occurrence:—

"Here the course of the river makes a sudden bend from the south-east to the south-west, and across the point formed by this bend occurs a patch, about half a mile long and from 5 to 10 chains wide in places, of a very waterworn coarse pebble drift and red ferruginous sandy clays, with irregular masses of brown ironstone. This drift deposit is the remains of the old bed of the stream, which in the Tertiary period flowed down the Cudgegong Valley, the present river channel having been subsequently eroded. The ranges on either side of the river, which consist of porphyry and Devonian sandstones, shales, and limestones, rise to a height of about 250 feet, and this old drift deposit is seen to have filled the valley to a height of at least 120 feet above the level of the river. (The barometric elevation of the highest level of the drift was recently determined by the writer to be 75 feet above the river.) Old shafts and surface excavations show that a considerable amount of work has been done; but as the ground, which is private property, is now idle, I could not ascertain if the prospecting had been carried on systematically. However, Mr. Waters, the manager of a company who had the ground about six years ago, informed me that he sunk a prospecting shaft 203 feet deep, and it was then abandoned. He states that the cinnabar was found, more or less, through the drift, from the surface to a depth of 50 feet on to a false bottom,

* Cat. Sydney Exhibition, 1870, p. 445.
† Mines and Mineral Statistics N.S.W., 1875, p. 201

and that the deposit without cinnabar continued to 117 feet, when the true bedrock of Devonian schists was met with; but at 170 feet, when in black schists, he cut through a vein 4 inches thick, dipping to the south-west, and containing a little cinnabar. He also informed me that this shaft was commenced with the object of striking, at a greater depth than it was sunk to, a ferruginous stratum which crops out on the range about 20 chains to the south, and dips to the north-east; but as this stratum is only soft sandstone, full of fossil shells, I do not think it has any necessary connection with the occurrence of cinnabar.

"Near the deep shaft Mr. Knoblanche pointed out a shaft which he and others had sunk and bottomed at a depth of 68 feet, and he also said that the cinnabar was found above the false bottom, which here occurs about 40 feet below the surface. The cinnabar taken from here occurs usually in sharp angular pieces, from half an inch in diameter down to the size of fine dust, and pieces have been obtained several pounds in weight."

Mr. Knoblanche informed the Writer that he found one piece weighing 2½ lb., and several ranging from 1 oz. to 10 oz. Mr. Anthes, after several years' experience, has found nothing larger than the pieces presented to the Writer, from 1 oz. to 1½ oz. Mr. Wilkinson's report continues:—"Often the surface of the cinnabar is somewhat rounded, but this may be the original form, and not due to attrition. I took some of the drift from close to the surface, and on washing it fair prospects of both cinnabar and fine gold were obtained; in these the grains of cinnabar were much waterworn, as might be expected, as the drift at the surface has been much denuded."

"Perhaps the most important feature connected with the occurrence of the ore is that the solid cinnabar is sometimes seen to gradually merge into or impregnate the clay or drift of the deposit in which it is found. This is, then, direct evidence that it has not been drifted by running water, like the waterworn pebbles and other material forming the old Tertiary lead, and that it has probably been derived from thermal water, which issued from the underlying Devonian rocks and permeated the Tertiary deposit."*

Mr. Wilkinson advised prospecting in the false bottom, to intersect any fissures through which the mineral water came up, which were to be followed down into bedrock. He also advised that the vein said to have been cut at 170 feet should be followed to surface. A good deal of trenching in the Devonian outcrop, higher up the ridge, has been done for this purpose without avail.

Mr. Wilkinson alluded to two adjacent ironstone lodes which he also regarded as of hydrothermal origin, but much older than the mercury springs, and thought it not improbable that cinnabar might be found in them, though he was unable to see any, nor yet in the drift alongside. These deposits have since proved to be very superficial, extending only to a few feet below the surface. A sample of the ironstone recently assayed for mercury in the Departmental Laboratory—No. 4316—yielded negative results.

Mr. Wilkinson, like Mr. Clarke, favoured a spring origin for the cinnabar, but differed in suggesting a strictly local source for its outflow. The latter, from his allusion to it as "drift lumps and pebbles," evidently regarded the mineral as foreign to the site.

According to Mr. Wilkinson's view, the mercury solutions probably rose from the immediately underlying Devonian strata or bedrock, permeating and impregnating the overburden of waterworn drift and clay. This opinion was induced by the sub-angular form of part of the cinnabar, the apparent

* Ann. Rept. Dept. Mines for 1884, p. 152.

Though cinnabar has not been specially identified with any particular geological period or lithological formation, yet, according to the associations of many notable deposits, those of the Cudgegong Valley immediately surrounding the local deposit appear favourable. In close conjunction are sandstones, conglomerate, shales, limestone, and intrusive porphyry. Search is desirable in and near the limestone, because of the extensive association of this rock with cinnabar, particularly in Mexico; also at and near the junction of the igneous and sedimentary rocks, and particularly up the course of the Cudgegong Valley.

It is noteworthy that the drift, particularly the coarse upper layers, contains red jasper and cherty pebbles and boulders, which are not representative of any of the closely-adjacent rocks. The nearest approach to a similar formation *in situ* is a chalcedonic and ferruginous outcrop at the junction of porphyry, limestone and sandstone on the opposite side of the river, about half a mile from the cinnabar drift. This will shortly receive some attention from Mr. Anthes, who examined it in company with the Writer.

To add to the difficulties of determination, it is confidently asserted by both Mr. Anthes and Mr. Knoblanche, that practical trials have failed to discover any trace of cinnabar above or below the present site on the river, though Mr. Clark recorded Carwell Creek as a cinnabar locality. This stream, as already stated, junctions with the Cudgegong just below the Cinnabar Mine.

In view of subsequent denudation, and redistribution of portion of the Cinnabar drift by the medium of the present river channel, it is impossible to accept at least a part of this assertion as conclusive; nor should the failure of previous efforts deter a further and more systematic effort to trace the mineral up stream to its source.

Mr. Warden Snape, referring to the Cinnabar deposit, wrote of the "well-known fact that quicksilver ore exists among the Cudgegong mountains,"* but did not substantiate the announcement by any definite instances of locality or occurrence, nor have any since been recorded.

In "Mineral Products of New South Wales," 1st Edition, issued by the Department of Mines in 1882, p. 89; and again in his "Minerals of New South Wales," London, 1888, p. 52, Professor Liversidge quotes "Mines and Mineral Statistics of New South Wales, 1875, p. 201," in reference to the reported occurrence of mercury at Wagonga, on the South Coast, "in a bed some 10 feet thick, about 90 feet above sea-level," which is evidently a mistake, as no mention is made of the fact in the work quoted, nor is anything known of the reported occurrence.

Mercury is also reported in the same work "in the casing of the Clifton Reef, Boorook"; and with cinnabar in a "clay lode, and in the surface grit at Calton Hill, Dungog."

In the 2nd Edition of "Mineral Products," 1887, p. 43, Mr. Harrie Wood, Under Secretary for Mines, records the Barrier Range as another cinnabar locality.

From the Australian Broken Hill Consols Mine, samples of cinnabar have been presented to the Mining Museum by a former Manager—Mr. George Smith. In the same institution are specimens of "iodide of mercury," deposited by sublimation on the sides of the vent cracks in the open cut workings in Broken Hill Proprietary, Block 11, since the outbreak of fire in the lower levels of that section. Iodide of copper—marshite—occurs in the Broken Hill lode, and iodine has since been detected in cuprite from the same lode. Possibly mercury occurs in the form of cinnabar in the Broken Hill

* Ann. Rept. Dept. Mines N. S. Wales for 1882, p. 49.

SKETCH MAP OF THE CUDGEGONG CINNABAR MINE

Parish of Wells. County of Roxburgh

Scale 0 10 20 Chains

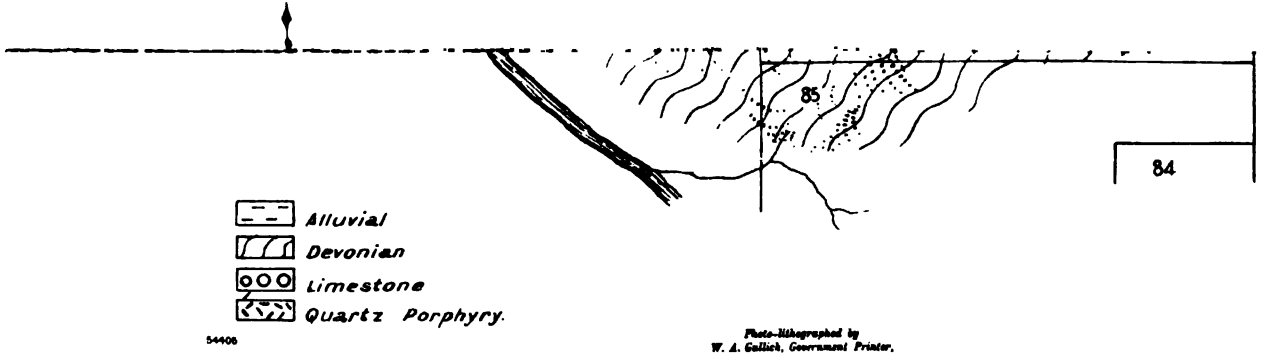

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Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

lode, where iodide of silver also is common, and a new combination of the two volatile metals—mercury and iodine—has been set up by the action of the fire in Block 11, though the natural iodide of mercury may be present as *coccinite*.

The latest discovery of mercury ore in the Colony is described by Mr. A. M'Intosh, of Grafton, as occurring on a branch of Corinda Creek, about 5 miles westerly from Woolgoolga on the North Coast. Two samples from this locality, consisting of ferruginous quartz with cinnabar, have recently been assayed in the Departmental Laboratory, with the following results:—$\frac{3\,3\,1}{0\,0}$, mercury, 0·26 %; $\frac{4\,2\,8}{0\,0}$, mercury, 0·30 %. Gold and silver traces in each case.

For a number of years cinnabar was found in alluvial gold-workings at Spring Creek, close to Bingara. Some fairly coarse worn fragments were presented to the Mining Museum by Mr. Grosbernd, of that town. In 1890 the mineral was discovered in serpentine at the locality mentioned, and shortly afterwards was examined and reported on by Professor David.* The following extracts are from his report:—"Three distinct geological formations are represented, as follows:—

"1. Claystones and limestones, probably of Siluro-Devonian age.
"2. Serpentine, resulting from the alteration of an ultra-basic rock of a decidedly intrusive nature. The lode deposit of cinnabar belongs to this formation.
"3. Alluvials, probably of recent geological age, derived from the breaking up of the claystones, &c., and serpentine, by streams of fresh water and other natural denuding agents.

"The claystones and limestones at Spring Creek strike in a N.N.W. direction, and dip E.N.E., at from 60° to 70°. The limestone bed appears to have a thickness of at least 100 feet, probably more, and is evidently stratified with the claystones." . . . . .

"The serpentines at Spring Creek occur in the form of an eruptive dyke mass, from 3 to 5 chains wide, striking either north-westerly or northerly."

At the time of inspection lode cinnabar had been found in only two shafts, 40 and 25 feet deep, 15 feet apart. The deposit is described in the report as having no true walls, being, in fact, a dyke of decomposed serpentinous rock, with interstratified layers of soft purple clay shale. The limits of the productive portions of the dyke could only be ascertained by constant testing as the work advanced.

"The cinnabar is disseminated chiefly through the mass of the dyke in small spots, from the size of a small pin's head up to that of a pistol bullet. It also occurs in thin films in joints in the dyke. The dyke has so far been proved to be cinnabar-bearing for a length of about 15 feet, with a maximum width of about 3 feet 6 inches, and a depth of 40 feet, this last being the maximum depth attained in the shafts. Although the greater part of the dyke material comprised within these measurements carries traces of cinnabar, the greatest measurements of any portion of it which may be described as being decidedly cinnabar-bearing were represented to us as being about 5 feet high, 4 feet long, and 1½ foot wide." A sample weighing 10 lb., carefully selected by Professor David from the bottom of the 25-foot shaft, was crushed and divided into two parcels, one of which was treated by the dry method, and the other by the wet, with corresponding results, viz.—metallic mercury, 0·01 per cent.

"Summary.—From the occurrence of the cinnabar along the line of contact of an eruptive dyke with a sedimentary rock, it is likely that the dyke will

* Ann. Rept. Dept. of Mines N. S. Wales for 1891, pp. 234–239.

continue to be cinnabar-bearing to a considerable depth, as most contact deposits of this kind show great permanence when followed downwards; unless, however, the dyke stone improves considerably at a depth in its yield of cinnabar, it is improbable that the deposit will prove payable."

Aid from the Prospecting Vote was granted to the best site indicated above, to enable a deeper test to be made (Pros. Papers, 91–1073), but at 78 feet work was abandoned, ostensibly on account of influx of water. Traces of cinnabar were reported to continue to the depth mentioned.

Professor David also visited, in the same year, the site of the first discovery of cinnabar, in the Upper Clarence district, made by Messrs. Kelly Brothers in M.L. 5, Parish Carnham, County Drake, about 3½ miles south-east of Lionsville, and described the occurrence in the following terms:—"A dyke, 12 feet wide, of felspathic rock allied to serpentine, containing cinnabar, distributed irregularly in spots and minute veins. This dyke has intersected the granite of the district at this locality, and is likely, I think, to be permanent to a considerable depth." Aid was granted to continue sinking, but was not availed of,

In 1895 a more important discovery was made, about 7 miles north-east of Lionsville, on which the following report was furnished by the Writer:—

REPORT ON A DEPOSIT OF CINNABAR NEAR LIONSVILLE.

Geological Survey Branch, Department of Mines and Agriculture,

Sir, 3 January, 1896.

I have the honor to report that, in accordance with your instructions, I have inspected the recent discovery of cinnabar on Yulgilbar Station, Clarence River.

The deposit occurs about 5 chains from the south-west corner of portion 15, parish Ewengar, county Drake, and about three-quarters of a mile west of the Clarence River.

The nearest settlement is Lionsville, distant about 7 miles in a south-west direction.

The discovery was made by Laurence Fox about twelve months ago through picking up a loose surface specimen of the matrix containing cinnabar. Actual prospecting began in February last.

A previous discovery was recorded in this district in 1891 at Horseshoe Bend, about 16 miles lower down the course of the river, and about 3½ miles south-east of Lionsville. This site has been surveyed as M.L. 5, of 40 acres, in the parish of Carnham. Mr. Geological Surveyor David reported on this deposit about March of the same year, and recommended aid from the Prospecting Vote for proving it. The occurrence is briefly described as* a dyke, 12 feet wide, of felspathic rock, allied to serpentine containing cinnabar, distributed irregularly in spots and minute veins. This dyke has intersected the granite of the district at this locality, and is likely, I think, to be permanent to a considerable depth."

The present report will be limited to a brief description of the country rocks, nature and apparent mode of occurrence of the mercury ore, present and suggested future prospecting, &c.

To attempt an estimate of the richness of the deposit, or of the quantity of ore likely to be available at the present initial stage of exploration, would be unfair, even if not altogether impossible. Sufficient data, however, will be adduced to justify the opinion that the prospects are decidedly encouraging, and far superior to those afforded by any previous discovery recorded in the Colony.

Previous Discoveries and Mention.

The localities of previous discoveries with reference to reports thereon may be briefly summarised as follows:—

Locality.	Authority.
Near Rylstone, Cudgegong River, county Roxburgh.	Rev. W. B. Clarke, Min. Statistics N.S.W., 1875, p. 201.
Mookerawa, and Great Waterhole of Ophir, county Westmoreland.	Prof. Liversidge, Min. N.S.W., p. 52.

* T. W. E. David, Prospecting Board Papers, 91-279.

Locality.	Authority.
*Clifton Mine, Boorook, county Buller	Prof. Liversidge, Min. N.S.W., p. 52.
Wagonga, county Dampier.....	,, ,,
Moruya, county Dampier	,, ,,
Calton Hill, Dungog, county Durham	,, ,,
Grove Creek, Abercrombie Mountain, county Georgiana.	,, ,,
Near Scone, county Brisbane.....	Mr. Dickson.
Spring Creek, near Bingara, county Murchison.	T. W. E. David, Ann. Rept. Dept. Mines N.S. Wales for 1891, p. 234.
†Crow Mountain District, near Barraba.	
Horshoe Bend, Clarence River, county Drake	T. W. E. David, Pros. Board Papers, 91-279.

Whilst writing this report a sample of galena and zinc blende with cinnabar has been brought to the Geological Survey Offices for assay, with a statement that it was obtained from Sunny Corner, Mitchell, county Roxburgh.

General Geological Features.

The country at the cinnabar deposit consists of hornblende granite, felsite, and augite-diorite, whilst in the immediate neighbourhood serpentine is largely developed.

The sedimentary rock of the district consists of altered slate, which has been referred to the Devonian formation by the late Government Geologist, Mr. C. S. Wilkinson.‡ The gold reefs of Lionsville occur in the latter where it has been intruded by granite dykes.

The special feature of the most important mercury mines of the world, viz., association of igneous rocks with sedimentary strata, is absent in the present case. So far as yet proved ore is confined to the igneous rocks.

Prospecting Operations.

At the time of inspection in October last prospecting operations had just been resumed after a short respite. Two shafts have been sunk 20 feet and 50 feet respectively about 3½ chains apart on a line bearing N. 15 degrees E., and S. 15 degrees W. These shafts are on distinct veins, which have an east and west trend. (?)

From the 50 feet shaft a line of shallow surface openings has been extended for about 29 chains in a direction 25 degrees north of east. These openings have been made wherever any of the characteristic fine-grained felsitic and chalcedonic matrix appeared at surface. In some instances the openings have been on loose and isolated boulders; in others, however, there is evidence of veins *in situ*, but not sufficiently pronounced to allow of a definite strike being determined for the complete line. It appears more likely that these veins are numerous. Traces of cinnabar were detected in most of these openings, but nothing approaching payable ore.

A second line of shallow openings has been made along a well-defined outcrop of similar rock. This line bears E. 5° S. from a point 80 links south of the 50 feet shaft. The openings extend for about 16 chains east from the shaft; the outcrop, however, can be traced at least twice that distance to the Clarence River, near the west bank of which it forms a bunch or "blow." Some years ago this bunch was prospected for gold. Cinnabar could not be detected here, though numerous freshly broken specimens were examined. I was informed, however, by Mr. T. Bassetti, one of the shareholders of the Cinnabar Mine, that that mineral could be identified upon crushing and washing the samples of the rock.

At the spot marked (C) on plan an opening 7 feet deep has been made in the outcrop referred to, and from that level a small opening or drive has been put in about 4 feet south. At the extreme north and south limits of the opening and drive, hornblende granite is exposed, the intervening rock being felsite, both being much weathered and decomposed. The peculiar feature here represented is the horizontal banding or marking of the rotten felsite by finely divided particles of cinnabar. The decomposed felsite is about 7 feet thick, and carries a small percentage of mercury—about one half per cent.—throughout that thickness. This site is one of the most favourable for prospecting.

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* These occurrences are evidently based on verbal or non-published reports; hence the references are non-committal.—J.E.C.

† Samples from this locality, Nos. 98-3,127 and 98-3,449, assayed in the Departmental Laboratory, yielded 11·2 and 3·0 per cent. of mercury, the matrix being quartz. No particulars are available of these occurrences.—J.E.C.

‡ Ann. Rept. Dept. Mines N.S. Wales for 1889, p. 202.

Detail of prospecting and appearance of ore in the workings.

The main 50 feet shaft being timbered for about 20 feet from surface, an examination of the appearance of the ore-veins near the surface could not be made for the purpose of comparison with those presented in the shallow openings above described. Below the timbering the discolouration obscured all traces, if any existed, of the ore to within a few feet of the bottom. In the south-eastern end of the shaft thin veins of cinnabar traverse irregularly about one foot of felsite country. In the north-western end a little cinnabar was just beginning to show at the bottom of the shaft.

Specimens of cinnabar were taken out at the upper levels several inches thick; the individual veins, however, at the 50-feet level have narrowed to about 1 inch at thickest. Little importance attaches to this pinching or thinning, because of the capricious occurrence of the cinnabar. Bunches of greater thickness are certain to be met with at intervals where vughs or cavities have been formed in the country.

From the 50-foot level a start has just been made to cross-cut southerly in the direction of the 20-feet shaft. The first shot had broken off a thin skelp from the side of the shaft, which revealed thin veins and faint impregnations of cinnabar traversing and colouring the felsite country. The actual thickness of the ore-body at this point cannot, therefore, be determined until the drive has been extended. A cross-cut in the opposite direction would also, perhaps, reveal an extension of the cinnabar in the country.

At the 20-feet shaft, the cinnabar, quartz, and calcite form the filling of a contact fissure between an intrusion of augite-diorite and the felsite. The cinnabar in the best specimens averages, perhaps, 1 inch in thickness in this vein.

The appearance of the ore in the small opening marked (*c*) has already been described. In the shallow openings, as has been mentioned, traces only of cinnabar have as yet been exposed.

Probable Mode of Occurrence of the Cinnabar.

As far as the limited amount of prospecting will allow of an opinion being formed, it appears probable that three or more parallel bands of felsite occur, containing veins and impregnations of cinnabar.

The ore-band on the 50-feet shaft is evidently distinct from that in the main line of outcrop, which strikes about 52 feet south of the shaft, because the felsite in that outcrop, as exposed at the opening marked (*c*), is but 7 feet thick, between well-defined hornblende granite walls.

A third band is represented at the 20-feet shaft, and possibly a fourth in the most northern line of openings.

Nature of the Country or Enclosing Rocks.

Characteristic specimens of the country rock were selected and forwarded to the Geological Survey Office for petrographical examination and determination. The following notes upon them have been kindly supplied by the Curator and Mineralogist, Mr. Card, A.R.S.M. :—

"Three types of rocks are comprised—

"(*a*) Fine-grained felsite of a greenish colour, weathering brown when fresh. This is the principal cinnabar-bearing rock, the ore occurring in veins and spots closely associated with quartz, and, to a less extent, calcite. These three minerals—cinnabar, quartz, and calcite—are of secondary origin; they do not occur in fresh, unaltered calcite, but their presence is always correlated with a general alteration of that rock. Pyrites is very generally present, but does not appear to possess any significance with regard to the origin of the cinnabar ore.

"(*b*) A holocrystaline rock marked "country." This consists of quartz, felspar, orthoclase, and much oligoclase (?) hornblende and a little magnetite, may be classed as hornblende-granite. A much altered form of this rock is of great interest, in that the alteration has been accompanied by an introduction of cinnabar, which occurs in small particles within the decomposed felspar, and more abundantly along the divisional planes of the hornblende.

"(*c*) Two specimens of fine-grained augite-diorite from No. 2 shaft."

Mr. Card's opinion as to the secondary nature of the cinnabar and associated minerals in the felsite and hornblende-granite, derived from microscopic examination of selected specimens is entirely confirmatory of the decision I arrived at in the field.

Though the cinnabar is mainly confined to the felsite bands, yet evidence is not wanting, macroscopic as well as microscopic, of a certain amount of impregnations of the granite itself.

The calcite and quartz occur in veins as well as impregnating the mass of the altered felsite. Small vughs occur which are lined with the crystal faces of the calcite. It is noticeable that when the cinnabar occurs as a vein, no matter how thin, it is entirely associated with the quartz, and separate from the calcite. In no instance in the vein-specimens collected could cinnabar be detected in the calcite. The quartz filling the veins has a translucent appearance passing almost into clear glassy transparency near the metallic vein minerals. Its outer surfaces form a series of mammillary curves covered with free terminating crystals. On these the calcite has been deposited. Part of the calcite is dark greenish-black; the colouring matter may be due to chlorite from decomposition of hornblende.*

The felsite in its normal condition is very fine-grained and greenish in colour, breaking with acherty conchoidal fracture. Pyrites is fairly abundant in it. Where decomposition has been set up the texture of the rock has become more closely crystalline in appearance owing to the replacement of portion of the fine felspathic material by crystalline calcite. The extent of the replacement may be judged from the following determination of the lime in an average specimen of the felsite from the bottom of the 50-feet shaft=Lime (CaO) 11·17%, equal to carbonate of lime 20·89%.

Nature of the Ore.

Associated with the cinnabar is an almost tin-white mineral, weathering bronze, containing copper, antimony, and sulphur. The copper carbonates, which occur in small quantity in the upper levels, have resulted from the oxidation of this mineral. The association of the latter with the cinnabar is too intimate to allow of the perfect separation necessary for adequate test for mercury in it. A complete analysis, however, of the mixed ore has been made by the Analyst to the Department, Mr. J. C. H. Mingaye, F.C.S., with the following results :—

Chemical Composition.

Metallic Mercury	43·68
,, Copper	6·87
,, Antimony	4·44
,, Arsenic	trace
,, Iron	·55
Alumina	trace
Lime (CaO)	1·26
Magnesia (MgO)	·21
†Gangue	30·46
Sulphur	11·46
Carbonic Acid	·44
Moisture at 100° C	·25
	99·52

Fine silver, at the rate of 9 oz. 6 dwt. 4 gr. per ton } No tellurium or
Fine gold, a trace (under 2 dwt.) } selenium detected.

The copper-bearing mineral penetrates the vein quartz in wedge or cone-shape forms. Mr. Card, who examined all the selected specimens prior to my return, suggests that it may be a mercurial fahlerz; further exploration may furnish sufficiently pure specimens for actual determination.

The first specimen of cinnabar from the Yulgilbar deposit assayed in the Departmental Laboratory yielded :—

Metallic mercury, 60·70%.
Silver, 6 oz. 10 dwt. 15 gr. per ton.
Gold, a trace (under 2 dwt. per ton).

This sample represented the highest grade ore in the principal vein near the surface of the main 50-feet shaft. The following samples were selected by myself from a band of decomposed felsite about 7 feet thick in the small opening at the spot marked (*c*) on plan.

[4057] "Picked." Decomposed felsitic material forming horizontal pink layers from 1 to 2 inches thick in a vertical section of about 3 ft. 6 in. :—

Metallic mercury, 48%.
Copper, a minute trace.
Neither gold or silver.

---

*Since determined to be owing to inclusions of fine acicular crystals of stibnite.
† Chiefly silica.

[4058.] "Average." Decomposed felsitic material, being an average sample selected from the full thickness in the above section :—

Metallic mercury, 50%.
Copper, a minute trace.
Neither gold or silver.

From the pink colour of the horizontal layers a much higher yield would have been anticipated from the "picked" sample than from the average of the whole thickness.

The cinnabar in the soft decomposed felsite must be in a very fine state of division, for its presence is only detected by the faint pinkish tinge imparted to the matrix. Possibly portion of the cinnabar may have been removed during the decomposition and weathering, as a sample of undecomposed felsite, having a pink tinge from included cinnabar, from No. 2 shaft, yielded as follows :—

[4056] "Lump."

Metallic mercury, 1·58%
Copper, a minute trace.
Neither gold nor silver.

Hence it is reasonable to expect a higher yield from the undecomposed felsite at a depth at the spot marked (C) on plan.

Origin of the Cinnabar.

Field observation and microscopic examination alike agree as to the deposition of the cinnabar from solution in siliceo-calcareous waters which percolated through definite cracks or fissures, and soaked laterally into the country as the corroding solutions attacked its more soluble constituents, and replaced them chiefly from the calcium or lime salts in solution.

It would, however, be premature to offer an opinion as to whether the mercury salts had a deep-seated extraneous source, or were originally leached in minute quantities from the contiguous or underlying granite and redeposited in the way described.

Ore at Grass.

Some of the richest patches of ore have been bagged, but little care has been taken with the bulk of the stone raised from the shafts ; hence any estimate of quantity of workable ore—fixing 5 per cent. as the maximum in this case—would be very approximate only. It is certain, however, that a fair proportion of the above grade ore could still be culled from the waste.

Further Prospecting.

The crucial question at the present moment, however, is—what quantity of workable ore is likely to be available in the mine?—a question which requires a practical answer such as systematic prospecting alone can give.

The sites most likely to afford a solution to the query would be the present shafts (A and B) and the site marked (C) on the accompanying plan. The prospecting should be in the direction of deepening the above shafts (including C), driving along the course of the veins, and crosscutting to ascertain the thickness of ore-bearing country.

Conclusion.

I am of opinion, from the mode of occurrence, that the cinnabar is likely to continue to great depths, but whether in sufficiently concentrated form to pay for extraction prospecting alone can prove.

The conditions of occurrence differ from those of the very few paying mercury mines of the World, yet the prospect of developing a paying deposit of moderate extent is decidedly encouraging and certainly superior to any yet obtained in the Colony.

As the existence of a mercury mine in Australia would be of first importance in such a gold-bearing country, I am of opinion that a share of the cost of proving comes well within the scope of the Prospecting Vote.

I have, &c.,
JOSEPH E. CARNE, F.G.S.,
Geological Surveyor.

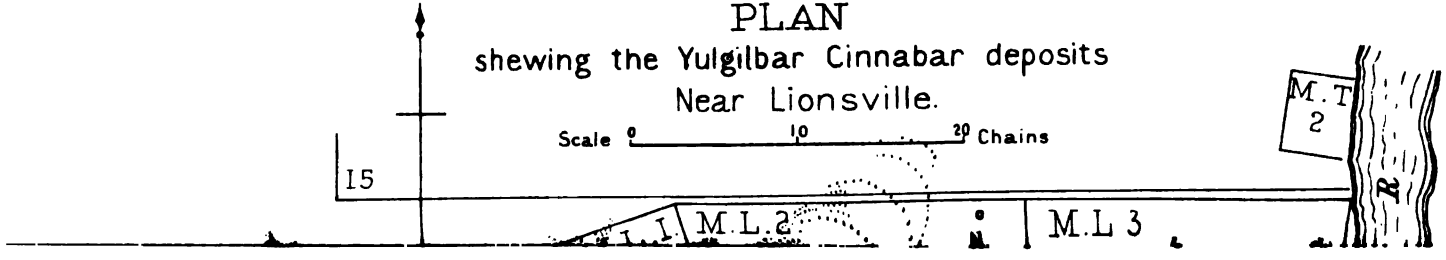
The Government Geologist.

In August of the present year a second visit of inspection to the Yulgilbar mine was made by the writer, for the purpose of noting developments to date. Whilst engaged upon the work, the Great Australian Quicksilver-mining Company, Ltd., was formed to secure and develop the property on more systematic lines than yet adopted.

PLAN

shewing the Yulgilbar Cinnabar deposits

Near Lionsville.



After the first inspection in 1895, aid was granted to the prospectors—Bassetti and Party—to deepen the main shaft, and sink another at a spot indicated. The former was carried down to 95 feet 6 inches, and then temporarily abandoned. The site of the second aided shaft in M.L. 2, was forfeited by the original holders, and shortly afterwards secured by Miller, Pollard, and Party, who sank 58 feet 6 inches. Again abandoned, it is now included in the new company's property. At a later date, through the agency of Dr. Flateau and others, two additional shafts were sunk about 26 and 30 feet, and an open excavation made on a later discovery.

Several distinct lines of cinnabar-bearing veins, proved by later developments, have been charted on the accompanying plan, and illustrated in section. Distinctive letters on the plan and in the text denote the position and identity of the workings.

The extension of prospecting has demonstrated two facts, viz., (1) a larger amount of cinnabar-bearing rock than formerly visible, and (2) the probable dependence of future operations upon the value or workableness of the lower-grade deposits, which alone offer sufficient promise of quantity commensurate with successful working, for it goes without saying that a minimum yield can only be set off by large, cheap, and rapid output.

Unfortunately the grade of the ore in the latest developments is disappointingly low, bordering so close, if not quite, on the unworkable as to put the contemplated immediate erection of reducing furnaces altogether out of the question at this stage. The first and most pressing necessity is extensive proving on systematic lines, and for this there is both justification and inducement.

The hopes engendered by recent experimental tests of a small quantity of picked ore are discounted by the limited supply of such grade in view. It is, therefore, imperative that the prospective supply and value of the larger deposits should be definitely determined by extending prospecting before a reduction plant is considered.

The brilliant hue of cinnabar—"vermilion"—renders it an intense colouring agent; hence an infinitesimal proportion imparts a very deceptive appearance to a veinstone or impregnated rock. Some of the highest-coloured and most promising-looking portions of the Yulgilbar ore are so lightly charged with this mineral as not to sensibly affect the specific gravity of the matrix. When it is remembered that cinnabar is a heavy mineral, possesssing a specific gravity of nearly 9 as compared with 2·6 to 2·7 of the matrix, the disappointing assay results of such samples can be more readily comprehended.

The principal samples selected by the Writer for assay during recent examination were subjected to the specific gravity test in confirmation of the laboratory results obtained. Further microscopic examination of prepared sections of the impregnated veinstone and enclosing rocks reveals at a glance the fineness and paucity of the colouring agent.

Active prospecting had ceased for some little time at the mines, but the Proprietary placed the workings in order, and afforded every assistance during the week devoted to inspection.

It will be seen by the plan that at least four distinct veins have been located, and more or less superficially tested; the most important, probably, being the junction line with the diorite dyke which intrudes the hornblende-granite country. Here the largest defined ore body is exposed, which, from its mode of occurrence, is likely to prove permanent to great depths. An interesting feature is the impregnation of both contact rocks with cinnabar, extending to at least the full width of the shaft (G). From the field and microscopic

evidence, it would appear that solfataric mineral solutions, containing mercury and a little antimony sulphides, followed the diorite intrusion along contraction fissures, permeating both dyke and country for a distance as yet unproved.

The diorite dyke is traceable on the surface from shaft G, through M.L. 1, and beyond, and has also been exposed in shaft E, and open cut B, as well as in small openings between G and E.

At E and M exactly similar surface conditions exist as at G. The dyke is very narrow—from 2 to 6 feet wide. Notwithstanding the discrepancy in strike, it is probable that the veinstone at O and P, near the Clarence River, agrees in more than resemblance with the dyke lode noted further west.

Geological Features.—An alteration in the nomenclature of the previously-recorded geological formations has been rendered necessary by extended field research and petrological examination of rocks from lower levels. The deceptive-looking formation previously described as felsite and altered felsite, proves to be lode material, a product of the transforming effects of the investing mineral solutions.

Becker states that "the rocks adjoining ore deposits have in many cases been greatly modified. Metamorphic rocks often appear to have been converted into or replaced by more or less dolomitic carbonates by the action of solutions."*

The following additional notes on the petrology of the field, by Mr. G. W. Card, A.R.S.M., are the results of later study of fresh specimens collected by the Writer :—

"'2068'. *Country Rock.*—Medium-grained crystalline, of a prevailing green tint, due to the presence of hornblende. Quartz, hornblende, orthoclase, and plagioclase are conspicuous in hand specimens.

"Under the microscope the felspars are seen to be zoned, and intergrowths of the two varieties are common. Nests of micro-pegmatite are present. The rocks may be most conveniently designated hornblende-granite (granitite of some authors).

"'2056'. Influenced by proximity to the vein. Felspar is clouded beyond recognition ; hornblende has been completely altered ; iron ores and cinnabar are disseminated through the mass, which is also traversed by calcite veins. In places it shows an approximation to a graphic structure.

"'3612'. From G shaft, showing a junction between the veinstuff and country rock. Both are cinnabar-bearing, and the line of contact is marked by the presence of antimonite.

"Under the microscope the cinnabar—along with the metallic ores—is seen scattered through the clouded felspar and vestigial hornblende. The junction with the veinstuff is marked by a narrow band of the latter, consisting of crystalline quartz with some calcite, enclosing blotches of cinnabar. This rapidly verges into a crypto-crystalline siliceous mass containing some calcite, throughout which cinnabar dust is scattered.

"'3621'. G shaft. From the dyke traversing the field. A compact pyritous green rock, with lighter mottling, due to a greenish-white felspar.

"Under the microscope it is seen to consist of plagioclase (perhaps an andesine variety), residual hornblende, chlorite, some quartz, calcite and iron ore. It is doubtful how far the quartz is primary.

"'3611'. From E shaft.—Under the microscope this has the appearance of being a portion of the dyke, highly weathered and mineralised. It is very fine-grained, and carries cinnabar.

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* Geol. of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey Mon., xiii, p. 292.

"A variation in colour suggested the possibility of a junction between different classes of rocks being represented, but the appearance is due to different degrees of weathering.

"'2064'. From E shaft.—Two specimens taken from the tip at different times. A very compact pyritous green rock, with a specific gravity of 2·87; glancing hornblende and lath-shaped felspar can be detected with a lens.

"Under the microscope it is seen to consist of lath-shaped and much altered plagioclase with some orthoclase, prismatic green hornblende, abundant pale green chlorite and granular, practically colourless, epidote, calcite and quartz. The latter mineral increases in abundance with the epidote, and is associated with it, sometimes showing crystal faces.

"It is possible that the epidote and quartz together may represent the larger felspars (probably lime-bearing) of '3621'. There is a slight tendency to an ophitic relationship between the chlorite and the felspar laths.

"The most suitable classification of this rock presents a difficulty. For general purposes it will, perhaps, be best to designate it a fine-grained quartz diorite. Scientifically, its somewhat peculiar constitution and structure, together with its fineness of grain, would bring it near the lamprophyres or aphanites.

"NOTE.—Although the chlorite might represent augite, that mineral is not certainly present, and the granular mineral, I am satisfied, is epidote. The designation, 'augite diorite,' applied by me on a former occasion to a specimen from E shaft cannot, therefore, be retained.

"'3622'. *The veinstuff*, from F shaft.—This consists essentially of impure calcite. Through this the cinnabar is scattered in small blotches, minute rods, and dust. It is associated with an equally finely-disseminated metallic ore—magnetite to some extent. The ore is traversed by thin strings of pyrites.

"Several other specimens were also examined. The siliceous vein-stuff is very compact, presenting, both megascopically and microscopically, a close resemblance to felsite. The earlier specimens were so regarded, but an examination of an extended series points to a purely secondary origin from the whole."

Further Development.

The main shaft (D on plan) has been deepened from 50 feet, recorded in the first report, to 95 feet 6 inches, and a level has been extended 11 feet easterly at 36 feet from surface. Close timbering obscures any inspection above the level; below it the shaft is inclined about 25° from the vertical, following the underlay of the vein southerly.

The face of the level shows a slight impregnation of cinnabar in the foot-wall. Evidence of fissuring is afforded by a vugh of considerable size, lined with chalcedonic silica.

Below the close timbering to the bottom of the shaft, a distance of about 59 feet 6 inches, the vein-stone averages from 4 to 7 inches in thickness, and is well defined at the lowest level. Slight impregnation of the country occurs in places, but the quantity of cinnabar is inappreciable. In the vein the cinnabar occurs as occasional streaks from ½ to 1 inch thick; sometimes two parallel streaks occur about 1 inch apart. The productive portions of the vein-stuff range from 1 to 3 inches in width, but are not continuous; in fact, all trace of cinnabar occasionally disappears for some distance. An idea of the irregular occurrence of the mineral in the matrix, both vertically and horizontally, is gained from its appearance in the shaft and drive. The ratio of cinnabar-bearing to barren matrix equals about 1 in 4 vertically.

A considerable amount of the full width of the vein exposed in the ends of the shaft at 93 feet was gadded out and brought to surface, where the best—or coloured—portion was picked out, broken small, and carefully sampled in the usual way, by mixing and parting. In the Departmental Laboratory large assays, in duplicate, of this material yielded (No. 3,373) at the rate of 1·09 per cent. of mercury. An average sample of the balance of the vein-stone extracted, similarly treated, yielded (No. 3,372) no mercury. The specific gravity of large pieces of these samples ranged from 2·69 to 2·71.

From the nature of the vein-stone, and the capricious occurrence of the cinnabar, it is apparent that a large amount of vein material—apart from the country extracted for the proper dimensions of the shaft or level—would have to be mined in proportion to the workable ore obtained by spalling and picking. Calculated on a specific gravity of 2·7 a cubic foot of vein-stone would weigh about 168 lb., or 13 cubic feet, to the ton. Accepting, on the evidence of the shaft, the proportion of workable ore as 1 to 4, 52 cubic feet of vein-stone would have to be mined to yield 1 ton of 1 per cent. ore.

As richer streaks of ore were found nearer the surface, allowance must be made for more favorable developments than at present visible. Possibly an additional per cent. could be safely allowed, bringing the average grade of the picked stone up to 2 per cent.

The ore recently experimented on in Sydney before the Directors and others of the newly formed Mining Company, was picked from the material raised during sinking of the main (95 feet) and a neighbouring shaft.

Though this vein is not in itself workable on account of the thinness and discontinuity of the ore-bearing streaks, it must be taken into account in estimating the possibilities of the whole property.

From the bottom of the main shaft strike levels are required, and a cross-cut to the dyke-lode, to intersect any intervening parallel veins that may exist. The dyke-lode would be cut from this level about 100 feet below its outcrop.

About 120 feet from the main shaft on the western strike, a more recent shaft (C) was sunk to about 30 feet. Time did not permit of it being unwatered. Judging by the tip, however, the vein in the granite is very narrow, and the impregnation of the country slight.

About 8 chains still further west, apparently on the same line, a small opening reveals the usual chalcedonic veinstone containing a little stibnite (stellate), pyrites, and cinnabar.

About 12½ chains E. 18° 20′ N. from the main shaft is another recent shaft (F), locally known as "Doctor's" shaft, sunk 26 feet on the most northern vein, represented by shallow openings at the time of first inspection. The strike of this vein taken in the shaft is N. 55° E., with a slight south-easterly dip.

The shaft is closely timbered to within a few feet of the bottom. Removal of timbering at 14 feet revealed the same thickness of veinstone as at 26 feet, viz., 12 to 14 inches, but more compact. At the lower level the vein is split in two by about 6 inches of country. On either side of the veinstone the latter is slightly impregnated with cinnabar.

Though the barren material and the immediate walls are referred to as "country" the whole is so impregnated with secondary calcite and silica from percolating solutions as to be more correctly described as barren lodestuff.

From the strongest part of the vein at the point of test—from surface to about 10 feet—some highly-coloured veinstone has been extracted in sinking, the hues ranging from bright pink to purple. As conflicting views were

entertained of the value of samples of this grade on view in Sydney prior to the recent inspection, tests were made in the Departmental Laboratory under Mr. J. C. H. Mingaye, F.I.C., F.C.S., of typical specimens of the highly-coloured and non-coloured veinstone, with the following results :—

No. 2,285—Coloured—.....Yield 0·92 per cent. of mercury.
,, 2,286—Non-coloured— ,, 0·10 ,, ,,

A further sample obtained by chipping the coloured blocks at surface yielded (No. 3,365) 0·825 per cent. of mercury.

From the ends and bottom of the shaft at 26 feet, 200 lb. (weighed) of ore were obtained by gadding out the full width of the exposed veins. This was broken small and carefully sampled in the usual way ; an assay (No. 3,363) of the test portion yielded less than 0·01 per cent. of mercury.

After selection of the average sample, 24 lb. of the remainder was weighed and reduced to one quarter, by rejecting everything destitute of cinnabar stains. An average of the reduced sample (No. 3,364) still gave a return of less than 0·01 per cent. of mercury.

The specific gravity of the "purple" ore, determined from a large piece, equalled 2·85 ; that of the "pink," 2·77.

A picked sample from the principal cinnabar make in the vein at 26 feet, about 2 inches thick, yielded (No. 3,368) mercury at the rate of 1·065 per cent.

The shaft at the present level is in poor average veinstone, though a very small proportion might be picked to about 1 per cent. It is apparent, from the superficial test made, that certain parts of the vein-stone contain about 1 per cent. of mercury, but the proportion of the latter to the bulk of the vein-stone cannot be estimated without further development.

The second deepest shaft (G on plan), locally known as Miller and Pollard's, was sunk at the site indicated by the writer as (C) in the first report, on the junction line of granite and diorite. The felsite previously mentioned has since been more definitely determined as an alteration product of the investing mineral solutions.

At the surface, evidence of a certain amount of leaching and redeposition was visible in the decomposed outcrop, which was horizontally banded with white and pink, representing alternate solution and impregnation at the various stages of weathering and decomposition. Similar conditions occur at the open cut (B on plan).

As previously recorded, samples (Nos. 4,057 and 4,058) from the outcrop yielded from 0·48 to 0·5 per cent. of mercury, whilst a sample of the less decomposed rock (No. 4,056) yielded 1·58 per cent. of mercury.

The present shaft was sunk 58 feet 6 inches a few feet south of the previous opening, cutting the lode material at some depth from the surface. At 46 feet, to which depth the water was lowered, the full width in the shaft is occupied by cinnabar-bearing lodestuff. The diorite in the centre of the exposed face is about 2 feet thick, and contains finely disseminated cinnabar throughout. On either side decomposed, or highly altered lode-stuff, passes gradually into hornblendic granite, cinnabar impregnating it so far as the limits of the shaft permit inspection. A sample taken from the full width exposed at 46 feet yielded (No. 3,375) 0·15 per cent. of mercury. Evidently the grade at this level is not equal to the lodestuff previously passed through, as the following assays show. Judging by the material in the shaft tip, which is indiscriminately mixed, sorting will be possible and satisfactory. A large sample of a fine-grained greenish rock (diorite?), crumbling on exposure, yielded (No. 3,369) 0·67 per cent. of mercury. A similar test of a pinkish felsitic rock, from the junction of the granite,

weathering brown on exposure, yielded (No. 3,370) 0·805 per cent. A sample of the coarse-grained granite from the junction (No. 3,371) yielded 0·570 per cent.

Along the junction of the granite and diorite which is well defined, chalcedonic quartz occurs, with nests of stellate crystals of stibnite on its surfaces.

On dissolving a little black calcite from the main shaft (D), a mass of fine acicular crystals of stibnite remained. It is possible that mercury is associated with it, forming the mineral "Livingstonite," though no tests have yet been made.

The diorite dyke, as before stated, can be traced to the west right through M.L. 1, and it is possible, notwithstanding the apparent discrepancy in the strikes, that the vein-stone at O and P, near the Clarence River, agrees in more than resemblance with the dyke line.

Between G and E several shallow openings reveal a common class of material, though in places more chalcedonic. At M, a sample of decomposed impregnated rock, exposed at surface, yielded (No. 3,374) 0·06 per cent. of mercury.

Shaft E, the 20-feet shaft of the first report, has fallen in; hence no fresh developments are to be recorded here. Still further west, at R, the dyke has been exposed at an excavation; traces of cinnabar only are visible at this point.

B represents an entirely new discovery, where an open cut exposes a width of about 17 feet of rotten hornblende granite, lightly impregnated with cinnabar. The conditions of occurrence at this point indicate a certain amount of progressive leaching and redeposition of the cinnabar, in the horizontal, curving, and vertical seams determined by the shell like weathering of the rock and the angles of the joint planes. It is noticeable that the principal deposition of the cinnabar is in these lines of soakage, though, not confined to them, as the mineral occurs in the rotten granite in the form of fine circular or semi-circular plates or stains exhibiting strong indications of secondary origin. It appears certain, however, that, as in shaft G, the granite will be found in depth to be impregnated with cinnabar from the original deposition.

The siliceous rock exposed in the cutting, which possesses the usual chalcedonic characteristics, probably represents the original line of fissuring and subsequent infiltration of heated mineralised waters from which percolation and impregnation of the enclosing granite ensued.

A test shaft and crosscut are needed at this site to determine the width and strike of this ore body, which at present are not definable. Until the unweathered rock is reached it would be hazardous to attempt an estimate of the value of this deposit. The extent of the surface impregnation is indicated by the result of a properly averaged sample of about 1½ ton of the material freshly extracted from the full width of the open cut, viz. (No. 3,366), mercury 0·035 per cent. An average sample of the seams and joint fillings in the exposed face of the open cut yielded (No. 3,367) mercury, 0·115 per cent.

Summary.

It will be seen by the aforegoing statement that whilst the quantity of cinnabar-bearing material in sight has been increased by further prospecting, the grade has not correspondingly improved. The line G to F will probably yield a workable quantity of ore, yielding from 0·5 to 1 per cent. of mercury. From the main shaft, D, and Doctor's Shaft, F, lesser quantities of similar

grade will be obtainable. From B nó ore approaching this grade is yet obtainable; whatever its prospects in depth, it cannot yet be taken into account. The question confronting the newly-formed company now is,—Can ore of the above grade be profitably worked under local conditions? Certainly, even lower grades are successfully operated on in Europe and Russia; but circumstances alter cases, and it is more than doubtful if the Yulgilbar deposits could be attacked on a commercial scale as they now appear. On the other hand, there is every reasonable inducement, as there is every need, for an adequate test to effectually decide their workableness or otherwise.

A little fine cinnabar occurs with gold in the bed of Sandy Creek, on the west side of Clarence River, close to the Yulgilbar Crossing. A slight amount of prospecting has been done in endeavouring to locate the matrix from which it is derived, and traces are reported in a rock somewhat similar to the vein rock at the main mines.

QUEENSLAND*.

The cinnabar country lies to the west of Kilkivan, between the heads of Wide Bay Creek and Kilkivan.

Several lodes are mentioned. One about 6 miles from the heads of Wide Bay Creek, and due west of the Black Snake Gold-mine, is described as of "brownish quartz"; and the central portion a conglomerate of broken-up particles of quartz cemented by deposition of silica from percolating waters, the pebbles being coated with small crystals of quartz. The country consists of micaceous and chloritic schists. The cinnabar occurs disseminated in the quartz, giving it a pinkish colour.

The Wolf Lode—about 1 foot thick—is composed chiefly of calcite, in which cinnabar occurs both in bunches and disseminated. The country being conglomerate, sandstone, and shales.

About 6 miles north-west of the Wolf Lode, the caps of several unprospected cinnabar lodes are reported.

About 1½ mile east of Messenger's, on King Bombi Creek, in altered sandstone and greywacke, is another lode, described as a gangue of calcite in the middle of a breccia of quartz and calcite; cinnabar and colours of gold being visible in the calcite.

Prospecting Lode.—Situated about 1 mile east of Messenger's, in coarse altered sandstone. Lode consists of a hard brown jasperoid quartz, stained with carbonates of copper. Cinnabar disseminated through the quartz.

Queensland Lode.—The Queensland claim of 80 acres—reported to contain three or four distinct lodes—of which the Queensland lode is the largest and richest, varying up to 7 feet wide in places, and averaging 4 to 5 per cent. of mercury from the dressed ore.

Mr. Rands states that 70 tons of ore yielded 6,000 lb. of mercury, with the roughest appliances for retorting and condensing the mercury. The lowest grade of lodestone yielded 1½ per cent., and the highest 23 per cent., whilst a small parcel of drift cinnabar yielded 60 per cent., the average yield being 3·8 per cent. from the lodestone.

Additional notes on these deposits, by the same authority, appear in the Annual Report of the Department of Mines Queensland for 1886, pp. 70, 71.

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* Report on the Geology and Mineral Resources of the Districts of Kilkivan and Black Snake. W. H. Rands, Assistant Government Geologist, 1886.

The *Queensland Lode*, at 42 feet, is described as consisting of a small rich vein of cinnabar in quartz on the eastern side of foot-wall, then 8 inches of quartz and calcite with cinnabar, and another mass of veinstuff in hanging wall; lode divided by a horse of mullock. Country, altered conglomerate or agglomerate "probably of volcanic origin, as it is full of angular particles."

Wolf Lode.—Level driven 170 feet on lode, consisting of "sandstone and shale underlying a volcanic ash much decomposed, and containing large angular pebbles." Lode strikes north-east, averages 1 foot in thickness. Matrix contains more calcite than the Queensland lode.

"A cross-cut lower down the gully cuts several lodes or veins. At 19 feet, one of 1 foot in thickness of calcite; at 55 feet, a lode of 1 foot 2 inches wide showing good ore; at 119 feet is a vein of calcite which appears to be dipping towards some leaders at 145 feet, which contain cinnabar; and at 200 feet the Wolf Lode is cut 4 feet 2 inches wide, and contains a very good percentage of cinnabar.

"So far as the work has at present gone the prospects for the future of these mines are very encouraging."

In 1891 (Ann. Rept. Geol. Survey Queensland for 1891, p. 17), Mr. Rands reported on a discovery of alluvial cinnabar on Messrs. Mactaggarts' section No. 2,447, at Kilkivan.

"A number of lodes carrying rich cinnabar have been worked on a ridge which runs through the selection in the form of a crescent. These lodes carry patches of a very high grade cinnabar, running in shoots, and are situated in a coarse-grained granite; surrounding the granite is a much altered porphyritic rock.

"The alluvial cinnabar occurs in a flat heading down from perhaps the richest of these lodes—the Commotion Lode. The wash-dirt consists of a granite drift, with large pebbles of the altered porphyritic rock, and contains small water-worn pebbles of cinnabar throughout it, with occasional pieces of a large size, sometimes over 1 lb. in weight. It averages about 4 feet in thickness, and has been met with in three shafts over a distance of 9 chains.

"The reefs in this selection, from the beginning of the year up to the end of October, have yielded 1·5 tons of quicksilver from 28 tons of ore. The total yield of quicksilver from the district is 4·1 tons."

Victoria.

Native mercury and cinnabar occur at Silver Creek, a western tributary of the Jamieson River. The site was briefly reported on by Mr. R. L. Murray, F.G.S., late Government Geologist of Victoria, in the following terms: "The formation consists of dark Silurian slaty rocks, and the mercury occurs in bands of these extending over a width of about 12 feet, principally in or near small strings of quartz. Globules of mercury are obtainable by breaking up and washing the slate, and can be seen in the cavities of the quartz. I was also able to detect small patches of cinnabar or sulphide of mercury in the quartz. The quantity of the metal is, however, altogether too small to be payable; and there is no evidence justifying the hope that it will become more plentiful at greater depth, though sinking a short distance to settle the question would be advisable. So far the discovery can only be said to be of scientific interest."*

* Report on the country between Wood's Point and Jamieson. Dept. Mines Vic. for 1898, p. 3.

The Jamieson Quicksilver Company was formed to work this deposit, and in the *Australian Mining Standard* of the 10th August, 1899, it was announced that "a first sale of quicksilver, the product of an Australian mine, was made on August 1st, when the Jamieson (V.) Quicksilver Company disposed of a quantity retorted from ore from their mine to the local United Gleeson and Sailor Bill's Company."

New Zealand.

The Ohaeawai cinnabar deposits in the Bay of Islands county, about 30 miles from the old township of Russell and 18 from Kawakawa, are the most important yet discovered in New Zealand. Though known as early as 1870, no attempt was made to work them until 1895, when an English syndicate began prospecting operations, under the supervision of Mr. André P. Griffiths, from whose paper on the subject the following notes are extracted* :—

"The Hot Springs, better known as Tuwhakino and Ngawha, around which the various quicksilver deposits are clustered, lie about 2 miles to the south-east of Omapere Lake. . . . .

"The face of the district, which at one time must have been the source of intense volcanic action and disturbance, is studded with old craters and extinct volcanoes. . . . .

"The country around the Hot Springs consists of a series of low, undulating, fern-clad hills. To the north-east and south-west these hills are mainly composed of fine blue limestones and firestones, which are covered by layers of varying thicknesses of 'green sand,' marly clays, and flints. All these rocks compose nearly the whole of the Tertiary Coal Measures of the island. . . . .

"These undulating hills form several crateriform hollows of varying diameters and depths, in which are found the Hot Springs and quicksilver deposits. . . . .

"The springs give off large quantities of sulphuretted hydrogen gas and occasionally a little steam. . . . .

"The deposits which have been formed by these springs consist essentially of beds of moderately hard brown and grey sandstones, or solidified siliceous mud, with layers of calcareous and siliceous sinter, through which the cinnabar has been deposited, together with native sulphur. They include also several layers of bituminous shale, containing an appreciable quantity of petroleum oil.

"There are, moreover, deposits of pyrites, with or without cinnabar, in some cases containing traces of gold and silver." . . . .

"The cinnabar occurs principally as lining small cavities and cracks in the solidified muds and green sand immediately surrounding the original fissures of the underlying basalt. Cinnabar is also found impregnating a fragmentary sinter, overlying the very fine muds or sandstone, but below the bituminous shale."

Mr. Griffiths records only one instance of the association of cinnabar and pyrites. Free mercury occurs only in very small quantities, apparently originating from decomposition of cinnabar.

The recent origin of the deposits is demonstrated by the evidences of active formation now in progress. Fine films of cinnabar are being deposited with

* The Ohaewai Quicksilver Deposits; by André P. Griffiths. Trans. New Zealand Inst. Mining Engineers, Second Session, 1898, ii, pp. 48-58.

native sulphur around the small orifices, at the bottom of trenches made during the prospecting operations, by the hot gases and solutions evolved from below; also from the presence of cinnabar in Kauri gum and in the charred trunk of a partially embedded tree.

The richest deposits are described as being nearest to the hottest gas vents; hence, at a very shallow depth a temperature was reached sufficient to preclude mining operations. A bore-hole put down 104 feet ejected mud to a height of 60 feet, followed by boiling water with H_2S in solution.

In their origin and mode of formation these deposits resemble those of the Pacific Slope, California, and of Steamboat Springs in Nevada.

Mr. Griffiths adds that the "cinnabar of Ohaeawai is associated with calcite, chalcedonic quartz, marcassite, sulphur, and bituminous matter."

"It would seem that there is no doubt that, in the case of the Ohaeawai deposits, the cinnabar was precipitated from hot ascending solutions or vapours near the surface. The gases which escape from these springs are mostly sulphuretted hydrogen, steam, and carbonic dioxide, with, possibly, a little carburetted hydrogen."

The following New Zealand mercury localities are also noted in the paper quoted:—Tokomairiro and Russell (native mercury); cinnabar at Puhipuhi, Kerikeri, and the Bay of Islands generally in the North Island. At Waipori, in the province of Otago, in the South Island, quicksilver is found as cinnabar, mostly in the shape of rolled fragments of pure sulphide.

Small quantities of cinnabar as a pulverulent deposit lining the inside of cracks and small cavities of quartz, along the outcrop of the Big Tin Lode at Te Aroah, also on footwall side of lode.

Cinnabar also occurs near the head of the Kaueranga River, in the Thames district.

A further discovery is reported in the *Australian Mining Standard* of the 23rd November, 1899, in the Waitahuna Ranges, 12 miles from Berwick, and halfway between that place and Waipori. Drift cinnabar traced to a lode 16 inches wide, in which about 3 inches of cinnabar occurs on the hanging wall.

THE TUWAKINO CINNABAR MINES, (OHAEAWAI), NEW ZEALAND, SITUATED ABOUT 20 MILES FROM THE BAY OF ISLANDS, AND 12 FROM KAWA KAWA; COMPILED FROM NOTES FURNISHED BY MR. S. L. BENSUSAN, O'CONNELL-STREET, SYDNEY.

"The Tuwakino Mercury deposits occur in a freehold of 465 acres, lying to the north-west of the site of the English syndicate's operations at Ohacawai."

"The cinnabar is brought from below by thermal action and deposited within the crater of a moribund volcano, in the last stage of solfataric activity. The watershed formed by the margin of the crater concentrates the rainfall and surface drainage into a pool at the bottom, about 60 feet in diameter. This water penetrating to considerable depths becomes greatly heated, and thus affords a ready means of diffusion of the increased temperature to the surface. For some distance round the margin of the pool similar sodden, heated conditions exist. Hitherto all attempts to mine round the pool beyond a depth of 10 or 15 feet were baffled by the sodden ground and heated water, and fumes of sulphuretted hydrogen, sulphurous, and carbonic acid gases.

"All round the pool for a considerable distance cinnabar is obtainable in every spadeful of earth. The problem, therefore, is how to overcome the difficulties enumerated, which have arrested operations in the past. After two visits to the locality a solution presented itself to the writer in a system of drainage, which the natural configuration of the country renders feasible. By draining the crater of its subterraneously heated water, the cause of the abnormal heating of the surface would be removed, and workable depths could be reached in direct proportion to the level of the drainage. Starting from the crater an irregular line of fissure extends for a considerable distance in a south-easterly direction, and at intervals along this line cinnabar has been met with, but no defined run of it.

"A few years ago, in company with my son, Mr. E. Bensusan, A.R.S.M., an examination and superficial test was made of the deposit. Both cinnabar and native mercury were obtained in several shallow holes round the pool, heat and fumes preventing more adequate testing.

"A second visit with another son—Mr. A. J. Bensusan, A.R.S.M.—was more successful, and suggested the solution already mentioned. By means of a small creek, which affords a natural outlet for the surplus water of the pool, we succeeded in lowering the standard level from 2½ to 3 feet. After allowing the drainage to continue for a few days, a hole was sunk a few feet from the pool to a depth which could not have been reached without the drainage effected. Here splendid prospects of cinnabar were obtained, from massive lumps to pulverulent material.

"Continuing sinking, at a moderate depth the ground became softer and hotter, and water oozed in; further operations had, therefore, to be abandoned."

"The result of this superficial test indicates the possibility of turning this valuable deposit to account. By means of a trench round the sides of the crater above the pool all surface drainage could be diverted to the overflow channel or creek, whilst a pump of moderate power could lower the accumulated water in the pool, and thus allow the surrounding cinnabar-bearing ground to drain and cool."

"The deposit was visited some years ago by Mr. Peake, A.R.S.M., who obtained a quantity of the cinnabar ore and conveyed it to London, where, subsequently, Mr. Snelus, of the Royal School of Mines, assayed it for a return of 55 per cent. mercury."

"As regards the relative richness of this deposit compared with the known cinnabar mines of the world, which, with the exception of Almaden and New Almaden, average less than 1 per cent. of mercury, all the assay returns of properly-taken samples from Tuwakino, so far as obtainable under the circumstances, ranged from ¼ to 6 per cent."

"One of the principal items of expenditure, particularly in connection with high-temperature cinnabar mines like the one in question, is securing and maintaining powerful ventilating machinery, an item capable of considerable reduction at Tuwakino by utilization of a waterfall of about 200 feet within the property itself. This fall is believed to be sufficient for generating all power requisite for developing the property, ventilation, electric lighting, &c."

"On the south-east of this property, following the line of fissure referred to, a plant was erected to treat the cinnabar found on that ground, but success does not appear to have attended the work undertaken. I do not think that the plant erected was adapted for the work. Furnaces taking charges of 1 cwt. are out of date, the most economical now used take 50-ton charges, or 1,000 times this quantity; the expense, too, is about a fifth or a sixth."

"The cost of treatment, recorded as 16s. per ton, is out of all reason. In my paper on the mode of occurrence and metallurgy of quicksilver, published in the *Town and Country Journal*, January, 1870, it is shown that in Germany they treat at a profit an ore yielding $\frac{1}{8}$ per cent.—value 6s."

"Some years since Messrs. Cox and Seaver reported on this property, and referring to a report of Mr. J. A. Phillips on a quicksilver mine in South America worked under similar conditions as to heat and moisture, stated that in one of the mines there they work levels 104, 157, 210, 260, and 310 feet from surface; that the heat of freshly-cut rock was often too great to be borne by the naked hand, but by a complete system of ventilation the mine was able to be worked successfully."

"As far as the cinnabar deposits at Ohaeawai are concerned, certainly those round the White Lake, I can see no reason why they may not be worked from open quarry, using modern, up to date furnaces of 50 tons capacity, when the shifting of the stuff and furnacing would pay with as small a yield as in Germany, or an eighth of a per cent. Probably it would pay to import German workmen, who know their business, and give them an interest in the results."

[Plates.]

Sydney: William Applegate Gullick, Government Printer.—1900.

NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 8.

REPORT

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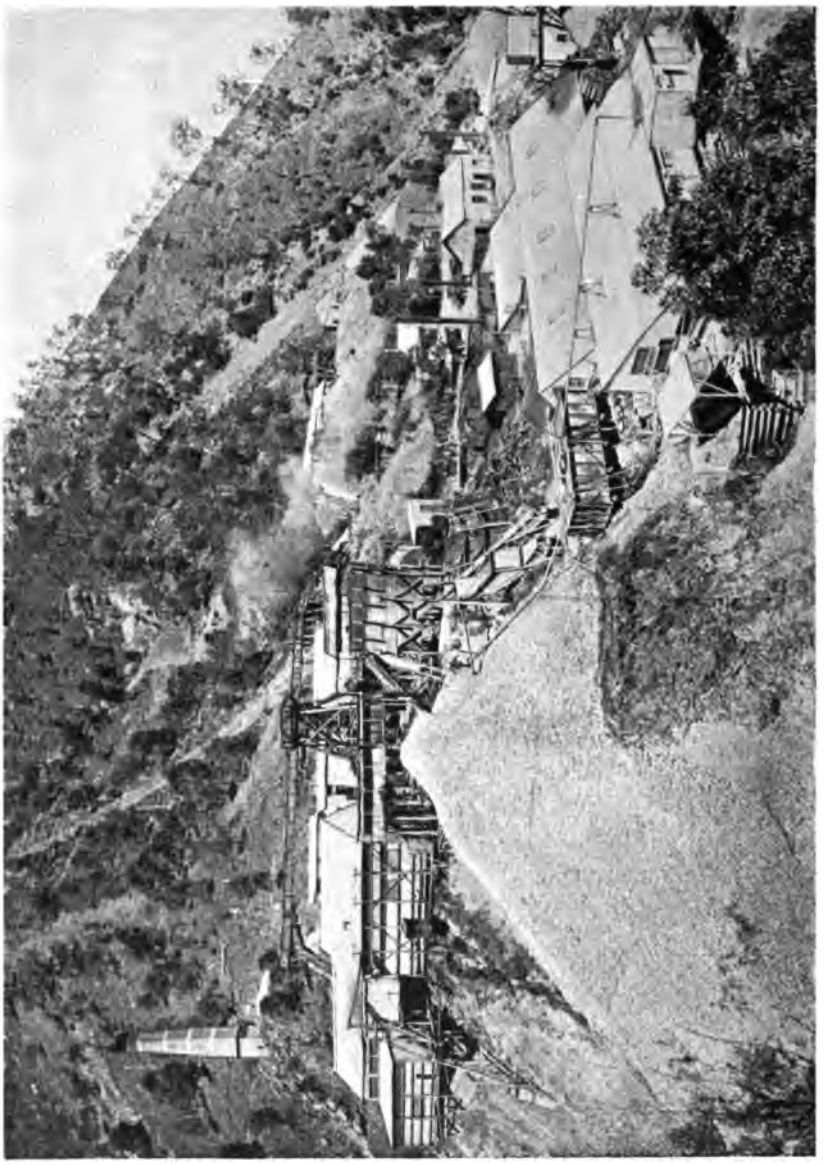
Frontispiece.



BAKER'S CREEK BATTERY, FROM THE WEST.

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LETTER OF TRANSMITTAL.

Geological Survey Branch, Department of Mines,
Sir, Sydney, 4 June, 1900.

I have the honor to transmit for publication Report No. 8 of the Mineral Resources Series, on the Hillgrove Gold-field, by Mr. E. C. Andrews, B.A., Geological Surveyor.

The geological survey of a considerable portion of this field was made by Mr. J. A. Watt, late Geological Surveyor; that gentleman, however, resigned his position on the staff at the end of March, 1899, and the survey has been completed by Mr. Andrews, who also examined the underground workings of the mines, and has furnished the accompanying report.

Hillgrove is one of the most important of the New South Wales gold-fields discovered in recent years, and it is of special interest on account of the occurrence there of lodes containing ores of both antimony and tungsten, associated with gold. The recovery of gold and antimony, from ores containing the two metals in conjunction, has always been a troublesome metallurgical problem, and in Hillgrove we have a field which offers a valuable opportunity to anyone who can devise a workable process for separating and saving the two metals. The scheelite deposits have recently been proved to be of considerable importance also, and it is hoped that the publication of this brochure may, by drawing the attention of the public to these interesting mineral deposits, have the effect of reviving the mining industry of the district.

I have, &c.,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines.

SYNOPSIS OF CONTENTS.

Report on the Hillgrove Goldfield.

INTRODUCTION.

THE immediate object of this report is to furnish a fairly clear conception of the field to the mining public by brief reference to the succinct points in the historical, topographical, geological, and economic mining features of the area under consideration. A map and sections of the field have been prepared. On the map are shown the relative extents of the various derivative and eruptive rocks of the Hillgrove area, as also the nature of their junctions one with the other. Thus the practical miner, knowing the Hillgrove area well, may take this as a guide wherewith to recognise similar rocks in contiguous areas. As an example, everyone using the Baker's Creek Tramline must have observed the great bluffs of rock and attendant long talus slopes exactly opposite to them in their progress downwards. With very few exceptions the miners of the field have assured me that it is a hardened slate, despite all assurances to the contrary. When it is known that this fine-grained rock is intrusive into the older rocks that contained the lodes, it is readily seen what a vanishing quantity the hope becomes of finding here the continuations of such reefs as the "Big" and "Little" lodes, which, however, would be quite feasible were the rock under consideration a belt of slate, as believed by the majority of men on the field.

The country is admittedly difficult to conduct geological observations in accurately. This is due in part to the highly metamorphosed character of many belts of the sedimentary formations, rendering it difficult to discriminate between fine-grained eruptive rocks and some of the more indurated and silicious slates. As an example may be quoted the curious belt of rocks running north and south through the Catholic School grounds, and ending southwards in a prominent bluff of rocks, overlooking for miles the valley of Baker's Creek, and known as Whittaker's Spur (Plate II). At first glance this might be mistaken for a granitic rock, although even a cursory inspection of its weathering reveals its sedimentary nature. Another and more difficult case occurs on the Metz side, on the flat ground west of Petersen's and Bewley's scheelite lodes. Here two long tongues of slate alternate with as many tongues of fine granite, and, to the untrained eye, the two are indistinguishable. Many have pronounced it all altered slate country. In reality, as seen on the map, the slate occupies the smaller area. Possibly the Four-mile offers the most bewildering spectacle, where granitic rocks in places succeed in palming themselves off as sandstones and slates, and altered bedded rocks conceal almost every trace of their derivative origin.

Special features of the report, exclusive of the main idea of the work, consist of notes on the numerous dykes which intersect the sedimentary formations; the prevailing types of lode formations; the antimony and scheelite lodes; descriptions of the machinery; and the methods of travelling on the steep hill sides.

As a starting point, and a basis of work, I had the partially completed map of Mr. J. A. Watt, M.A., B.Sc., formerly one of the Geological Surveyors in this Department. Having made use of his main east and west line of junction of the eruptive and sedimentary rocks, I preferred to undertake most of the work *de novo*, as it was necessary to get well acquainted with the surface before attempting the underground survey. With one or two exceptions, our boundary lines, &c., are fairly coincident. The various junctions of eruptive and sedimentary rocks to the east in the difficult country of the Four-mile Creek, and those also to the south of Bakers' Creek, were, previous to my reconnaissance, a blank page. For these I am alone responsible, as also for the squaring-up of the map in all directions. The broken character of the country, the veiling of the various lines of junction under masks of shingle, and the great metamorphism of the rocks, necessitated a far greater expenditure of time than would be required for the examination of ordinary country. Besides these, the absence of landmarks was felt, and some of the junctions are, at best, only approximately true. I was enabled to secure a fairly good series of photographic negatives, dealing with subjects of mining and geological interest. In all departments of the work I have to acknowledge the great assistance of Mr. M. Morrison, Field Assistant, who accompanied me throughout the trip. Especially valuable was his aid in dealing with the difficulties that beset us in attempting to make out the chronological succession of the eruptive rocks.

I desire to here cordially thank Mr. G. Smith, one of the directors of Baker's Creek Gold-mining Co., Mr. Thomas and Mr. M'Namara, of the West Sunlight Mine, for notes on the general history of the field; Mr. H. M. Porter, Manager of the Proprietary Mine; Mr. S. McGeorge, Manager for Baker's Creek Gold-mining Co.; Mr. R. Sharp, Manager of the Eleanora Mine; Mr. F. Cape, Manager of the Sunlight Mine; Mr. S. Mills, Manager of the Consols Mine; Mr. T. Snow, of the Golden Gate Mine; Mr. A. Nicholson, of the Starlight Mine; Mr. J. Fuller and Mr. S. Sullings, for permission to make tracings of their mine plans, for information concerning the gold yields of their respective claims, and for notes on the history of their respective mining properties; also, all the underground managers and other officials, from whom, without exception, I received every assistance in the way of mine measurements, and other items of interest in the underground workings.

2. HISTORY OF THE FIELD.

Three decades ago the population of Hillgrove was confined to a few stragglers on the Metz side, who divided their time between helping at the local station during the shearing season and occasional prospecting along Baker's Creek bed. That was before the discovery of gold and antimony in payable quantities. To-day some 3,000 people draw their means of livelihood, directly or indirectly, from the product of the reefs; and Wyalong, a field of still later growth, is to-day the only field in New South Wales ahead of it in gold returns; while so far is the latest report of Baker's Creek Co. from sounding a note of decadence, that the final fortnightly clean-up for the half-year totalled 1,285 oz. of smelted gold.

Plate II.

To face page 6.

WHITTAKER'S SPUR, SEEN FROM THE SOUTH.

At first all the difficulties attendant on pioneer mining in broken country had to be encountered; horses, bullocks, and men dragged loads of ore while they climbed the steep sidelings—so steep sometimes that bullocks have been dragged back by their loads; landslips were common in the treacherous ground at Swamp Creek; dollies were the only appliances available for extracting the gold; and after tremendous expenditure of energy in hauling the ore up the gorge slopes, long monotonous journeys had to be undertaken by teamsters over execrable roads to Grafton or Tamworth before their loads could be delivered over to steamers or trains. Batteries and good tracks came slowly at first, but with the advent of payable ore conditions were altered. Tramways were constructed on the hill sides, large batteries were erected to facilitate crushing operations, and at the present time the Sandon Electric Light and Power Co. are preparing to drive the machinery and light the mines by electricity.

Having thus glanced generally at the history of the field, it is proposed to note briefly the chronological order of the more important events constituting the principal factors in the making of the Hillgrove of to-day.

Haversbed Bros. and Thomas led the way in 1877 by finding an antimony lode quite close to, and south of, the present Hopetoun Reefs. A parcel of 4 tons 17 cwt. was obtained by them from the outcrop, carted to Grafton, and thence despatched to England; £17 15s. was paid for the consignment. Negotiations were then entered into by this party with Hudson and Co., of Sydney, for the purpose of erecting antimony smelting works.

About the same time Campbell Bros. mined for antimony on the spur now named after them, and lying a little north and west of Baker's Creek battery. Moore, Speare, and McBean followed by taking up an 80-acre block on the Southern side of this spur, and afterwards took up Portion 58. These portions were taken up under the now obsolete "mineral conditional purchase" conditions, and worked for antimony. At first the mining was performed by tributors, but the owners found these latter shooting much of the ore won down the hill slopes, so as to pick it up at their leisure in the creek below. To prevent this loss to themselves, Moore's party took up an additional portion of 80 acres, known as M.C.P. 110.

In 1878, Brackin, Daly, and Elliott found a long line of reef containing antimony. This was afterwards worked as the Isabella lode. It was discovered on the Hillgrove side of the gully, whereas the previous finds had occurred on the Metz slope. Another event was the discovery of the Paradise and No. 9 lodes, two antimony reefs, which after keeping company for some distance diverged from their original course, and struck out nearly at right-angles to each other. The continuations of these two lodes were found in the flat country above the gorge, and from them one parcel of 10 tons was extracted.

Another antimony lode was worked on Brackin's Spur, a prominent landmark near the junction of the Baker's and Four-mile Creeks. This lode turned out some very good ore. Junce and Kerseller, acting for an Armidale syndicate, opened up antimony smelting works near the head of Swamp Creek and treated the various antimony ores of the field.

Up to this time there had been no thought of gold, and, even when specks of the precious metal were discovered in the Garibaldi Reef, its significance was not appreciated, owing to the difficulty experienced in extracting gold from an antimony admixture. The first speck seen on the field occurred in No. 2 shaft of the Isabella line of reef, now known as the Garibaldi Shaft. Aaron Smith is credited with the observation.

After the Eleanora and Garibaldi had been worked for some time, the attention of the companies prospecting them was turned to the winning of gold, and in November, 1881, Mr. G. Smith was appointed by an Armidale syndicate to manage the Garibaldi property. Supposed payable gold was then found at the Eleanora, and a party of six from Armidale, exclusive of Brackin, Daly, and Elliott (who, as discoverers of the lode, were included) formed a company and took up a gold lease of 20 acres. Four tons were made up for the first parcel and sent to Sydney. Quick bought these on assay and shipped them to England. The return was 7 oz. of gold to the ton. 89 tons in all were sent away. At the end of 1882 and beginning of 1883 the Eleanora was put into a company of 12,000 shares. A 10-head battery, brought over from Stawell, in Victoria, was erected by Scoular. The battery was then increased to 25-head, and to anticipate slightly, G. Smith, who had bought back into the company, made preparations for the erection of 70-head of stampers in 1892, and which, in 1899, were utilised for the first time.

The Garibaldi Reef was still worked for antimony. In 1882 came a revival in the demand for this metal, and a consequent rise in price. In 1882 it brought £7 per ton in Armidale. Hargreaves, the owner of Hillgrove Station, had been working an antimony claim on the top of the Swamp Creek Falls. This was known as the continuation of the Paradise and No. 9 lodes. In 1885 he leased the claim to tributors, and imposed a royalty of £1 per ton on all the ore won. 141 tons of antimony were taken out of this reef in 1885 and part of 1886. Besides this amount, Hargreaves had previously extracted 91 tons. A slump occurring in the price of antimony, the value of crude ore going down to £4 10s. per ton, the lodes were prospected for gold. From these lodes, at various times, about 2,000 tons of crude antimony have been extracted, 500 tons from the top and 1,500 tons from the creek sides. The ore was carted up the gully at first by bullocks (Plate III), and afterwards drawn by trams.

In the middle of 1886 the Carrington lode, occurring in the granite north of the Eleanora, and worked previously for antimony, was opened up for gold. A sample of 2 tons was forwarded to the Sydney Mint. The total return was 5 oz. 13½ dwt. In the same year this lode was inspected by Neilds of Adelaide and Deitz of Temora. It was then formed into a company and prospected again.

In 1887 came the real opening up of the gold-bearing reefs of the district, when the Little, Big, Middle, and Baalgammon veins were discovered; when the lodes worked by Moore, Speare, and McBean, on the west side of the Baker's Creek gorge, were found to contain gold, and when the Cosmopolitan, Hopetoun, Starlight, and Centennial claims were taken up for gold-mining purposes.

In the early part of that year, G. Smith was invited by J. Elliott, G. Phillips, T. Asche, and N. O'Donnell to inspect something which they had unearthed on the Metz side of the creek. Accordingly, Smith started from Hillgrove to cross the gully, intending on the way to prospect the creek bed for himself. While crossing the stream he lighted on a piece of quartz carrying gold. Fixing the spot, he determined to trace the gold to its source on his return. A search led him to the outcrop of the Big Reef, where he found a strong body of stone, 4 ft. wide, containing much fine gold, the metal standing out above the weathered reef. He brought up a large piece of the stone to the town flat and dollied it there. So incredulous, however, were the local people that it required some little persuasion to arouse sufficient enthusiasm in a party from Armidale to bear the expense of the application and

survey of the lease of 15 acres. During the pegging out, the surveyor employed discovered a piece of quartz containing gold near the south boundary line. Smith traced this to a lode running parallel to the boundary throughout the length of the ground. Thus unwittingly was the "Little" or "Smith's" line of reef pegged in. Afterwards it was ascertained that the last-discovered reef underlay into the surveyed portion.

It was on the 27th March, 1887, that this 15-acre block was applied for. The finding of gold near the creek, however, was not absolutely a surprise, as an adjoining lode, named Hill's Reef, had yielded gold four years before. The inception of gold-mining operations on the Big and Little Reefs was attended with astonishing results. From 2 tons 6 cwt. taken from an open cut, the Sydney Mint obtained 105 oz. 9 dwt. by crushing. A large dolly with spring pole was next put up, and with this primitive battery, G. Smith and brother, two Millers, with two men on wages dollied out £2,500 worth of gold in four months. The property had been known as the "Four Brothers' Mine," but the name gradually fell into disuse. The first reef discovered was christened the "Big Reef," and the erstwhile "Little Reef" was renamed "Smith's Reef." A meeting of the shareholders offered one fifth share for a 5-head battery. W. B. Neild accepted the offer. A company of 100,000 shares, paid up to 17s. 6d., was floated, since which time the company have paid fifty dividends, amounting to £267,500. This mine has crushed 117,635 tons of ore for 188,812 oz. of gold (exclusive of that contained in the concentrates) since it started mining operations. Owing to its persistent success it has been the greatest factor in the stability of the mining industry at Hillgrove.

To return to the Sunlight, the finding of which slightly anteceded that of its richer neighbour, the Baker's Creek property. This was the find which Smith was requested by Elliott and O'Donnell to inspect. The discovery was made on Moore, Speare, and McBean's M.C.P. 109, and the reef previously worked for antimony. Two men, named A. Argles and J. M. Dalzell, representing themselves as capitalists, had just arrived from Sydney to examine a new find called the "Root Hog," situate to the north of the Sunlight, and now worked as the Hopetoun. Elliot and Party entered into an agreement with Argles and Dalzell concerning the Sunlight, as the latter considered the land to belong to the Crown. Moore, Speare, and McBean contended that the land was theirs, while Elliott's party pegged out and claimed to hold it under miners' rights. Argles and Dalzell, meanwhile, recognising the claims of Moore and Party, leased block 110 from them, while Elliott and O'Donnell contested the point, and thus rose a series of litigations, extending over two years, at the end of which period, Moore and Party were left undisputed owners of blocks 58, 109, and 110.

The total amount of gold won from the Sunlight reef since 1892 is 36,873 oz. 6 dwt., and from the West Sunlight since 1894 is 19,000 oz. These amounts are exclusive of gold contained in the concentrates, and only represent a portion of the actual gold yield, as the mines have been worked since 1887 and 1888.

The best of the gold deposits contained in the granite lie in that belt of country occupying the western slope of the gorge north of Baker's Creek property. The first claims pegged out included the "Root Hog," taken up in 1897. These were then formed into the properties known as the Hopetouns, and taken up by a Victorian company in 100,000 £1 shares.

In the same year (1887) that the reefs of the Baker's Creek property were discovered, Thomas pegged out, in the coarse granite to the north of the slate belt, a portion containing certain reefs, which appeared to him to lie on the same line as the Eleanora. The property was taken up as the North and

South Cosmopolitan, and worked for gold. Mining for the latter was soon discontinued in favour of antimony mining, as gold was scarce, but antimony very plentiful. Afterwards the land lay idle till some three years ago, when Thomas, Hay, and Parr pegged out afresh a part of the original lease, amounting to 2 acres.

Last July the Cosmopolitan and Carrington were amalgamated into "The Hillgrove United" by Fuller and Robinson. From the Cosmopolitan Reef, for the past two years, crushings have yielded 1 oz. to 27 dwt. of gold per ton of stone; 20 tons last year were crushed for 23 oz. 13 dwt. For these figures I am indebted to Mr. Fuller, of Hillgrove.

Some little time after the commencement of mining operations at Baker's Creek, "The Consols" Company took up a lease to enable them to work the southern extension of the Middle Reef and the north-west continuations of the Little and Baalgammon lines.

Among the more determined efforts to prove the north and south continuations of the Big and Little Reefs may be mentioned that of the Baker's Creek Gold-mining Company South, who drove two tunnels south of the Baker's Creek Company in a N.N.E. direction. The main tunnel has since been carried to a distance of 2,054 feet into the hill by the present Proprietary Company. Then, on portion 176, the Mount Carrington Gold-mining Company drove a tunnel into the hill 500 feet; but, after encountering a granitic dyke 10 feet wide, the idea was abandoned. To the north, Petersen and Party, Elliot and Party, as well as others, have prospected in vain; in fact, the whole of the later intrusive granitic mass to the north and west of Baker's Creek Company's workings has been pegged out and prospected, the men considering the fine-grained mass to be an indurated slate. The exceedingly rough country to the south-east—a tract pierced with dykes—has also been largely prospected.

Another line of reef that has been searched for beyond its present limits is the Sunlight. The West Sunlight Company, with their double lode, almost undoubtedly have the western prolongation; while Trimms and Murgatroyd, searching in the broken country to the east, claim to have hit the reef also.

The laying down of light tramways facilitated mining operations for such mines as the Baker's Creek, Sunlight and West Sunlight, Hopetoun, Cosmopolitan, and Carrington, all of which are situate in the gorge. The Baker's Creek Company led the way in 1889, and then followed in order the Hopetoun, the Sunlight, the Carrington, and West Sunlight.

Until telephones established communication between the top and bottom of the tramline, the Inspector of Mines would allow no passenger traffic.

The finding of high-grade scheelite near the town in the coarse granite is interesting, inasmuch as, so far, very few similar occurrences have been reported from New South Wales. The ore is confined to small lenticular patches in veins. The principal suppliers of the mineral are Keyes and Party, Maddricks and Party, The Hopetoun, and Wade's Party, near Brackin's Spur. Over 70 tons of scheelite were put into the market for the year ending December, 1899. Most of the ore was of good quality, varying from 50 per cent. to 60 per cent. of tungstic acid. Ten shillings per unit was paid for ore over 60 per cent. Keyes and Party, from two blocks, supplied 20 tons; Maddricks and Party, about 15 tons; Snow and Son, about 15 tons; Willmott and Company, about 20 tons. Most of this has been won during the half year ending December, 1899.

At present the Garibaldi, Eleanora, West Sunlight, and Golden Gate are not working, although the West Sunlight is expected to resume operations in February, 1900.

Summary.

1877.—Finding of antimony in quantity at Hillgrove. Working of the Sunlight for antimony.

1878.—Brackin, Daly, and Elliot found Eleanora Reef (antimony). Claimed Government reward.

1881.—Gold found in Garibaldi.

1882.—Revival in price of antimony, giving the mining of this material an impetus. Eleanora formed into company of 12,000 shares.

1883.—Hill's Reef discovered and worked for gold. Ten-head battery for the Eleanora brought over from Stawell.

1886.—Carrington Mine discovered.

1887—Gold discovered in Sunlight Reef. G. Smith discovers Big Reef. Little and Middle Reefs opened up. Hopetoun discovered. Cosmopolitan Reefs pegged out. Sydney Mint crushed 2 tons 7 cwt. of stone from Big and Little Reefs for 45 oz. 17 dwt. per ton. Smith and party dollied out £2,500 worth of gold in four months.

1888.—Baker's Creek put up 10 head of stampers.

1892.—Baker's Creek increased crushing plant to 40 head of stampers.

1898.—Baker's Creek and Sunlight Reefs working with 40 head of stampers, Consols with 15 head, and West Sunlight with 20 head.

1899.—Eleanora increased battery to 70 head of stampers.

Gold Returns (exclusive of Concentrates).

Dates.	Oz. of smelted gold. oz.	dwt.	gr.
Eleanora, July, 1892, to Dec., 1899	31,477	11	3
Consols, Sept., 1897, to July, 1899	3,550	12	0
Baker's Creek (total), March, 1887, to Dec., 1899	188,812	0	0
Sunlight, Jan., 1892, to Dec., 1899	36,873	6	12
West Sunlight, Jan., 1894, to July, 1899 ...	19,000	11	0
Garibaldi...	Not known		
Golden Gate	2,100	7	0

Baker's Creek paid fiftieth dividend. 70 to 80 tons of high-grade scheelite won from lenticular patches in coarse granite.

3. PREVIOUS LITERATURE BEARING ON THE SUBJECT OF MINING AT HILLGROVE.

(*a*) In the Annual Report of the Department of Mines for 1883, Mr. C. S. Wilkinson, late Government Geologist, has a report on "The occurrence of Gold and Antimony Lodes at Hillgrove."

(*b*) Mr. J. E. Carne, F.G.S., Geological Surveyor, mentions the presence of scheelite in this locality in his pamphlet entitled "The occurrence of Tungsten Ores in New South Wales," published as No. 2 of the "Mineral Resources" series of this Department.

Various reports by the Inspectors of Mines and Wardens may be found in the Annual Reports for 1889, 1890, 1895, and 1898.

4. PHYSICAL GEOGRAPHY.

(*a*) Drainage system. (*b*) Topography. (*c*) Ravines. (*d*) Scenic features. (*e*) Meteorology. (*f*) Influence of the ravines on mining industry.

(*a*) Drainage System.

Baker's Creek and the Gara River, the main drainage channels of the Hillgrove area, belong to the eastern or coastal system of rivers, their united streams forming one of the head waters of the Macleay River.

(*b*) Topography.

To one approaching Hillgrove from the west the general effect produced is that of evenly undulating country, with isolated and rounded hill masses rising above the gentle curves of the granite downs. Here and there late basalt outflows have produced extensive flats, and on these grass grows more luxuriantly than on the poorer contiguous granite areas. Clusters of curiously-weathered granite tors are of frequent occurrence; these, in silhouette, at times are grotesquely suggestive of animal and human outlines. The continuity of the granite plateau is broken, however, at the town itself, where a general east and west line of granite and slate junction occurs. This is the signal for a marked change in the topographical features of the district. The creeks, which have flowed through the table-land in broad and shallow beds, precipitate themselves over great ledges of rock nearly 1,000 feet in height. Several natural trenches, the outward and visible sign of the eroding waters, have been deeply cut into the slate and granite plateau. These are disposed in, approximately, a north and south direction, and contain, throughout their length, a marvellous wealth of rugged slope and precipice. In the vicinity of the town four such cañons may be crossed in an east and west traverse of two or three miles. Near the mines, Baker's Creek ravine is 1,500 feet deep, while a few miles lower down, where beds of soft black slate occur, the steep escarpments rise 2,500 feet above the creek-bed. Where the granite has been the rock attacked by the denuding influences, the gully sides are generally rough, and show large rounded blocks resting upon cuboidally-jointed rock-masses. At the heads of Baker's, Swamp, and the Four-mile Creeks the sides are quite precipitous, varying from 600 to 1,000 feet in height (Plate III).

(*d*) Scenic Features.

The scenic effects are at times weird and grotesque. In the granite country rectangularly-jointed masses simulate piles of masonry. Generally tall, ribbed, precipitous bluffs obtain in the slate country (Plate III). In Swamp Creek a great bluff of slate occurs, almost 1,000 feet in height, and exhibits bedding or joint planes bent almost into a semicircle. Sometimes long, narrow belts of slate, determined in shape by the cleavage, creep across the valleys. In places these tongues and solitary needles of indurated slate reach skywards for hundreds of feet. The sides of the slopes are barren as a rule, and lack both that warmth of colour so frequently seen on the sandstone bluffs of the New South Wales gorges and the dense vegetation that swarms at the bases of ravines generally.

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SLATE AND GRANITE JUNCTION, HEAD OF SWAMP CREEK.

(*e*) Meteorology.

The altitude of Hillgrove township is 3,150 feet above sea-level, and the average rainfall is 40 or 41 inches per annum. Severe frosts occur in winter, which have a tendency to split the rocks, while during the summer the sun glows fiercely on the unprotected sides of the gorges. Very high winds desolate the plateau at times. One during my stay in November uprooted scores of trees, and shifted huge stones that tore up the mountain tracks as they darted down the gully sides. Thus, besides the transporting effect of water, the power of the wind and the alternations of heat and cold must not be overlooked as factors in the carving out of these ravines.

Severe floods are at times experienced. In 1893 a rush of water moved an angular granite block of forty tons some two chains lower down the creek, and this on fairly level ground.

(*f*) Influence of Ravines on the Mining Industry.

The commercial significance of these hill slopes with respect to the mining industry at Hillgrove will be seen at once :—

(*a*) As a source of expense.—In the need of costly tramways to expedite conveyance of material up and down the slopes, where beasts of burden would be almost useless ; in the discounting in value of minor mineral deposits situate on the slopes of the gorges, owing to cost of haulage and element of danger involved in coping with the numerous landslips which occur, particularly in the antimony area of the Swamp Creek.

(*b*) As a source of gain.—As a set-off to the loss entailed in travelling and hauling on the steep sidelings may be mentioned the power obtained by water conserved in dams situate on the table-land, and conveyed down the slopes in pipes ; and the facility with which some of the reefs may be won by tunnelling into the hill from the gully sides.

5. GEOLOGY.

Various rocks of the field. Chronological order of geological events. (*a*) Sedimentary rocks. (*b*) Eruptive rocks—First granite intrusion, second granite intrusion, third intrusion, fourth and latest intrusion ; dykes. The slopes of granite bosses. (*c*) Metamorphism ; the sedimentary rocks ; the "kicking" slate ; the eruptive rocks. (*d*) The lodes—Direction of strike ; origin ; later movements ; cross courses ; occurrence and nature of ores. (*e*) Geological events subsequent to the formation of lodes—Metamorphism ; erosion ; old river beds ; Tertiary basalts ; erosion of rocks to form present ravines. (*f*) Petrological notes on the Hillgrove rocks.

Geology.

Broadly defined, the geology of the field consists of a series of fine sedimentary rocks, broken into and altered by several granite masses, and by dykes of granitic origin. On the eroded portions of these ancient masses lie quartz pebble drifts covered by basalt flows.

Chronological Order of Geological Events.

In the present state of our knowledge, it would be premature to insist on any definite order of succession among the various strata and subsequent eruptive rocks.

The slates and quartzites are probably the oldest rocks of the field. These are traversed by dykes of granitic origin, and these in turn appear to be of great age, as they have shared in the whole of the regional metamorphism of the district. It is probable that the older fine-grained masses of granite lying in the Four-mile Creek, and in its neighbourhood, either sent out the older dykes that pierce the sedimentary rocks, or were at any rate contemporaneous with the older dyke-forming epoch.

To the south a coarser and greenish granite has been intruded into the slates. In places it is a felspar-porphyry. It is in the shape of a huge bar running east and west, and cut off, both to the east and west, by the coarser granite of the field.

Subsequent to this intrusion a large mass of biotite granite, or granitite, penetrated the older masses, and cut across the slates and other sedimentary rocks from east to west.

The bluff of rocks, west and north-west of the Baker's Creek Company's workings, represents the material forced into the slates by the latest granitic intrusion. It differs from the other plutonic masses in not being of coarse texture, but showing to the unaided eye simply a very fine crystalline appearance.

After a long period of quiescence, during which the great granitic bosses were first exposed, then eroded nearly to their present level, Tertiary basalts made their appearance, diverting the rivers into new channels.

(*a*) Sedimentary Rocks.

Possibly the oldest rocks on the field are the altered slates, schists, and quartzites. These in the Hillgrove area itself are confined to a sub-rectangular shaped mass, two miles in length and some three-quarters of a mile in breadth. A narrow strip of altered slate is continued on from the main mass in a westerly direction, and contains the Sunlight lodes in its course. This small belt averages but a few hundreds of yards in width. A great bar of granite has cut across the direction of the slate outcrop, some 1,000 yards below Baker's Creek Mine workings, and from that point the slate continues for miles down the creek, but with a slightly varying strike. On the gold-field itself, the sedimentary rocks consist of slates, knotted schists, mica schists, quartzites, siliceous schists, and siliceous slates, much contorted in places, but generally preserving a strike N. 20° W. Between Murgatroyd's tunnels and the Garibaldi dam the strike passes gradually from N. 8° E. to N. 23° W., and the dip changes from a slight easterly direction to an almost insensible westerly one. In one place, between the tunnel and the dam, the dip is vertical. At Whittaker's Spur and the Swamp Creek, local disturbances have bent the slate sharply. Two readings taken in the Swamp Creek were respectively 35° and 70° towards the west.

In rare instances both dip and cleavage show beautifully, and the slates are black and blue-black in colour, with white intercalated bands coinciding with the strike of the beds.

Mr. W. S. Dun, Palæontologist to the Geological Survey, has examined several of these rocks in thin sections under the microscope, for the presence

of radiolaria. One of these had the appearance of a radiolarian rock, but was too much altered for the satisfactory preservation of these organisms. Others exhibit no traces of radiolaria.

Again the slates often pass insensibly into a knotted or spotted schist. Near the centre of the area occupied by the derivative rocks, a curious rock mass occurs, which on superficial examination shows a striking resemblance to a fine-grained igneous rock. It is, however, of sedimentary origin. Interbedded with this rock are thin beds of spotted or knotted schists. By determining the direction of the schist and "highly altered" rock-junction, the strike of the latter was arrived at; it was N. 10° W.

Towards the Four-mile Creek, quartzites, siliceous schists, and mica schists occur, but the rocks are too altered to show signs of dip and strike at the surface. For a similar reason there appears to be no trace of former organisms that may be contained in the strata. A soft, black, cleaved slate, occurring several miles down the creek was searched for fossils, with no success however, although everything seems favourable in the slate for the preservation of organisms.

Several prominent jointings occur in the slates. Of these two are very marked, one occurring at an angle of 15° to 20° to the strike of the beds, and dipping at a high angle. The other is of lower angle, rarely exceeding 20° or 30°. Another subordinate system of jointing is also common. Plate III illustrates well the most pronounced of these jointings.

(*b*) The Eruptive Rocks.

The First Granitic Intrusion.—The remains of an old granite rock are found in various parts of the field, particularly in the bed and eastern slope of the Four-mile Creek, near its head. In places it has the appearance of a fine-grained white sandstone, in others of a fine-grained but much altered granite. In the Four-mile Creek it appears to be broken into by the main granite mass of the field. In the bed of the same creek, a mass of angular fragments of a fine-grained rock are cemented together by larger and smaller veins of a younger and coarser intrusive rock, which has broken up the finer-grained mass. These fragments may belong to an older granite mass. Professor David has informed me of the frequency with which, in New England, a coarse granite has broken and intruded into an older finer-grained rock. In walking from Bolivia to Deepwater, along the railway line, one sees splendid illustrations of this intrusion of coarse granite into fine, exposed in the cuttings. It is possible that the oldest dykes of the field which show so much evidence of metamorphism, represent one phase of this older granitic intrusion. These dykes are green in colour, and weather out into a yellowish or brownish earth showing much decomposed micaceous material.

Second Granitic Intrusion.—There is another granitic mass on the field which appears to be older than the wide-spread coarse granite. It runs as a belt east and west across the southern part of the field, and is exposed only in the Baker's Creek gorge, where the coarser granite has truncated it at both extremities. In a small creek on the Long Point Spur, a whole mass of sub-circular fine-grained fragments have been caught up by the coarser granite rock. The phenomenon occurs near the granite and schist junction.

The rock is generally compact, fine in grain, and green in colour owing to its wealth of decomposed ferromagnesian minerals. The red soil resulting from its decomposition, its green colour and its weight are suggestive of a more basic origin than granite. Its innumerable segregations are notable, both in forms of veins and irregularly shaped masses, as much as ten yards in

diameter. The edges of these latter shade off insensibly into the enclosing magma. The minerals enclosed are quartz and felspars. The coarse segregations have the appearance of gabbros or diorite from the colour, the occurrence of the ferromagnesian constituents, and the great quantity of striated felspar. Near the junction of this rock with the slate, a mass of broken fragments occurs similar in appearance to kindred displays mentioned in previous paragraphs. This broken mass is not confined to a mere selvage in width, but persists for a distance of some two or three hundred yards, measured at right-angles to the strike of the slate and granite junction. Both at the Long Point Creek spur, and in the bed of the Four-mile Creek, this brecciated appearance occurs near the sedimentary rocks.

Huge dykes have been sent by this mass into the surrounding slates. They are highly altered; they show large white felspars and at times elongated blue quartzes; they have generally been thought to be diorites.

The Third Granitic Intrusion.—This, the main acid intrusion on the field, is important as regards its mass, its action on the sedimentary rocks, and the part played by it in the formation of the lodes.

In appearance this coarse granite is black on fresh fractures, by reason of the abundance of dark mica, and it also contains much plagioclase. Large idiomorphs of felspar, with corroded contours lie scattered plentifully throughout the mass. It is markedly gneissoid, crushed or otherwise altered in places.

Most of the gold and antimony lodes are connected with this boss, besides which the scheelite veins, almost without exception, are contained in it.

The Latest Granitic Intrusion.—The last granite outburst connected with this field occurs as a bold escarpment, 400 yards wide, 1,500 feet in height, and in position exactly opposite the Baker's Creek Mine tramway. It is exceedingly fine in texture, very tough, and has a glistening appearance on fracture. Most of the miners of the field are so deceived as to its true structural affinities as to designate it a baked or hardened slate. Plutonic rocks consolidate as fairly coarse crystalline mineral aggregates—to wit, the other granites of the field—and are supposed to have cooled at great depths below the surface, but cooling appears to have acted rapidly in this granitic mass, as though it had consolidated nearer the surface.

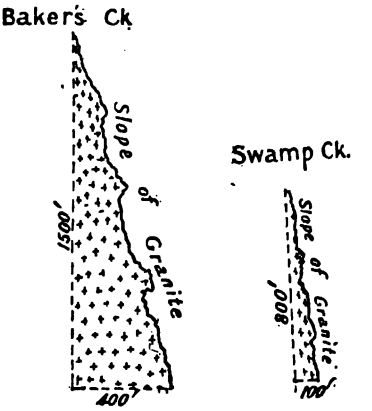
The tailings in the creek near the Sunlight, Baker's Creek, and Proprietary Mines, obscure a history that would otherwise be easily read concerning the relative ages of three of the granitic masses of the field. Enough is exposed, however, to show that a long tongue of felspar porphyry, sent out from the green granite to the south, passed through Murgatroyd's and Trimm's tunnels, and was cut through by this latest eruptive rock. Beyond the fine granite, traces of the felspar porphyry tongue exist as dykes near Baker's Creek workings. This fine rock has also sent narrow felsite dykes into the slate. In one place near the Sunlight bridges, the hard black slate is pierced by narrow ribbons of felsite, more or less parallel to each other. Many of them are of the character of small sills, and, generally speaking, they supply clear evidence of the intrusive nature of the granite. The habit of this intrusive rock is more that of a dyke than a boss. Measurements taken near the Sunlight Reef indicate a vertical slope for the granite at that particular spot. Two or three long lines of dykes passing through the coarse granite were traced to within a couple of hundred yards of the granite under consideration. In appearance they were similar to undoubted dykes sent out from the fine-grained rock.

Dykes.—A reference to the map will serve to show how many occur in the restricted area of the mines. The beds of Baker's and Swamp Creeks are full

of them. Several accompany lines of reef—*e.g.*, the Eleanora. Others break across reefs. Some appear to have partaken in all the general metamorphism of the area—*e.g.*, the Eleanora and Freehold dykes. Another felsite dyke, four feet wide, running like a wall up a vertical bluff of slate two hundred feet high, outcrops near the Garibaldi dam. This rock contains numerous crystals of hornblende and epidote. The Little Reef in its northern end, the Creek near the Sunlight battery, the Upper and Lower Cooney tunnels, are all intersected by these granitic intrusions, while great felspar porphyry dykes, ten feet wide, cross the line of the Little Reef, Portion 176, Murgatroyd's tunnel, and Baker's Creek; these proceed from the green granitic mass to the south.

The Slopes of Granite Bosses.—Observations in Baker's Creek, Swamp Creek, and Four-mile Creek, give much steeper angles of slope for the granitic bosses than might be expected. The junction of slate and granite on the eastern and western lips of the falls was obtained in these creeks, and the position of the junction between these two rock types was also fixed in the creek bed. Then, by drawing a line at right-angles from the junction in the creek to a line joining the two fixed points on the edges of the falls, an approximate idea of the original granite slope was obtained. In Baker's Creek the granite had advanced 400 feet in a vertical height of 1,500 feet—*i.e.*, less than 1 in 3. In Swamp Creek the advance was 100 feet for a vertical drop of 800 feet. In the Four-mile Creek the slope was almost nil, and in the Sunlight lode, also, the slope approximated to the vertical. The slope of the Sunlight granite was observed per medium of the tunnels.

Sketches showing the slopes of the Granite Bosses in Baker's and Swamp Creeks.



(*c*) Metamorphism.

The metamorphism of the slate has been alluded to before. In places the rock has been altered almost beyond recognition, soft black slate being changed to hard siliceous varieties; rocks belonging to the nodular and spotted schists, and one resembling a fine-grained variety of eruptive rock. In both slates and older granites numerous lodes occur, and cross-courses of two pronounced types, both of which have altered the country, causing heaves from an inch to twenty feet.

In one place in Baker's Creek a peculiar phase of metamorphism is found in the so-called explosive slate. Along the Little Reef, on the lower levels, particularly Nos. 10 and 11, and in the upper levels of the Sunlight Reef, a variety of slate is worked that tends to explode or "kick" spontaneously. On striking, or on boring with a drill, this treacherous ground will fly out in all directions with great violence. On one occasion a couple of miners were drilling a hole in No. 11 level, when a "kick" occurred. A lump of stone, about 50 lbs. weight, was hurled out of the wall, and after passing through a 3 in. x 2 in. scantling, cut a man's body in two. Another driller lost an eye, another his nose and scalp, while many have been buried in the débris attendant on one of these outbursts, but these have escaped with bruising. Stulls placed normally to the walls are frequently smashed, or the ground about the foot of a stull is driven out, leaving it on a small shoe of slate remaining on the foot wall. For days before a "kick" occurs along a bad level the slate "spits," and fragments are given off at intervals. All that is then needed is a sharp hammering or a drill hole to be put in for an outburst to take place. Along No. 11 level this slate occurs in slabs, polished on the outside, while inside it differs in no respect, macroscopically, from an ordinary hard black slate. The best examples of the "kicking" rock have the marked jointing of the field, but break with conchoidal fracture, and are curiously curly in structure.

It seems to be merely a result of great pressure, derived probably from the compressing forces exerted by the various local granitic intrusions. In driving levels this "kicking" is rarely observed. It is only when the pressure is still more relieved, as for example, by stoping, that the slate bursts out with the force of a dynamite shot. Some observers imagine the slate has been subjected to fusion, and they find an analogous case in that of the Prince Rupert drops, which are pieces of molten glass, suddenly cooled by causing them to drop into liquid while in a molten state. A thin crust of cooled glass forms immediately, but the whole central portion is held in a state of such strain that on allowing one of the "drops" to fall, the thin outer ring of rapidly cooled glass cracks, the pressure is relieved, and a violent explosion occurs. The two cases are not identical. In the first place the "drops" are of fused material, while the palæozoic slate has suffered nothing like fusion. Even had the slates been fused, at the great depths they occur they could not have cooled quickly, so as to have a pent-up central portion inside a rapidly-cooled shell. Another group of inquirers has referred the origin of the explosions to pent-up gases in the slate, but this is as untenable an hypothesis as that of fusion.

If an elastic body could be pressed down by some Herculean force so as to occupy a smaller space than it would under normal conditions, and then secured in this position by strong steel clamps, so fixed as to form an immensely thick "strong box," encasing the imprisoned body, we can form some idea as to the behaviour of the slate. The removal of one or two clamps would make no perceptible difference in the state of the imprisoned body. As, however, the releasing process was continued, there would come a time when perfect equilibrium would exist between the forces of expansion and compression. Then the least further release would result in an explosion. This seems to be the condition of things on the Little Reef levels. Several series of granitic intrusions have occurred in the vicinity, causing, especially during the last intrusion, great compression of the slates. The driving of a level along this tightly packed area results in "spitting" and minor "kicks" only, as the side thrusts of the walls and other forces would keep the solid rock fairly intact. As, however, stoping went on, thus relieving pressure in more than one

direction, the expansive and compressive forces would approach the state of equilibrium. This would be heralded by the "spitting" of the slate. When the state of equilibrium was reached, the least tap with a hammer would result in a disastrous explosion. Frequently this stage is reached by firing a shot; tapping, after this, is attended with "kicking."

Another feature is the metamorphism of the older granites of the field, where crushing has taken place. In some of the coarser granites, notably the green basic variety, south of the gold area, a structure has been induced by dynamic metamorphism that resembles the bedding of stratified material. In others the quartzes are elongated into sub-elliptical forms, and in places appear to be of secondary origin. Frequently whole areas of rock are polished, and coated with green material, wrongly called serpentine by some mining men. Plumbago is present in some quantity in portions of the older green granite, and flucan derived from the crushing of this rock is at times quite black and tough.

(*d*) The Lodes.

The largest and most important of these have a north-westerly and south-easterly course, and underlie to the east at a steep angle, varying from 0° to 25° from the vertical. In the case of the Eleanora and Freehold Reefs, large dykes follow their strike closely. The Big and Little Reefs, the Middle Reef, and Hill's Reef, are crossed by dykes. When dykes follow the reefs they are older than the lode material. Thus the Eleanora and Freehold Reefs appear to have opened along the line of the dykes, and to have been charged with minerals subsequently. The continuation of some of the large reefs into the main granitic mass, the general parallelism of the strike and dip of all the main reefs, the ore characteristics of the same, and the general north and south tendency of the principal cross-courses, all tend to prove a common age and origin for the lodes, and that origin to be traced to the main granitic upheaval. It is very probable that the main lodes were determined by the upheaval of the granite and the cross-courses by its settling down; the lodes dip to the north-east, and occur on the eastern side of the main granitic axis of the district. The Sunlight lode has opened again since that time, possibly as a result of the latest granitic intrusion. The Middle and Little Reefs intersect, but do not throw each other. According to Mr. Barnet, formerly underground manager in the Baker's Creek property, the Middle Reef was strong at the intersection, while the Little Reef was reduced to a few irregularly-distributed quartz threads.

A predominating system of cross-courses runs north and south, and underlies to the east, and gives rise, generally, to "right-hand" heaves of the lodes. Their underlie varies from 0° to 20° from the vertical. Gold frequently occurs in their neighbourhood. Another set of cross-courses have a more east and west direction, and these also have thrown the reefs. In isolated cases reefs have been thrown as much as 12 feet out of their course. In the case of the Eleanora Reef, the lode occurs on both sides of the dyke. Where the dyke has made a slight roll horizontally, the reef appears to "sit" on the bulge so caused. When the reef opened alongside the dyke, and the hanging wall slipped on the foot wall, a massive slate breccia was formed, which was cemented by quartz and sulphide of antimony, deposited from ascending thermal waters.

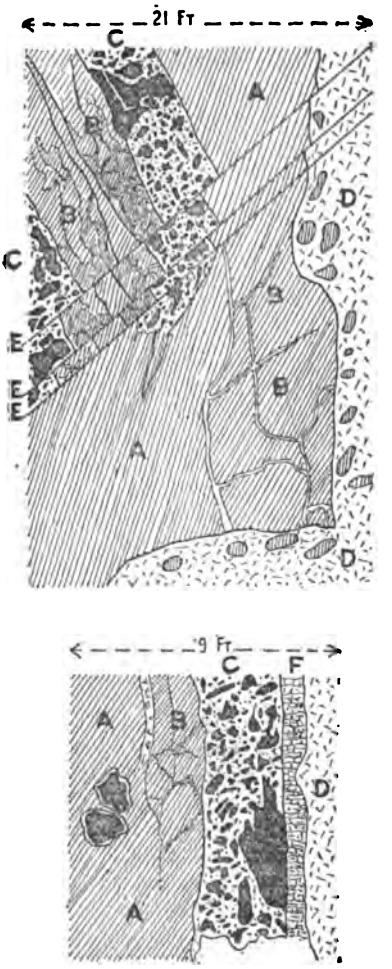
The reefs consist principally of quartz alternating with stretches of barren crushed slate and quartz, or hard slate. Polished surfaces are frequent, as also flucan bands. In the granite lodes a green selvage of crushed ferro-magnesian rock is visible.

The scheelite lodes pinch in and widen out with astonishing rapidity. They are mostly small deposits, and antimonite is associated with the scheelite. In the Hopetoun, gold is said to pinch out when the scheelite makes, and *vice versa*.

The principal matrix of the gold is quartz, but stibnite also is present in great quantity, sometimes as magnificent crystal specimens filling vughs, at other times in hair-like masses, and at others amorphous. Some specimens look much like Jamesonite.

The quartz is translucent to white and opaque. The breccias of the Eleanora and Sunlight Reefs are distinctive, both as to the general shape of the slate fragments and the quartz cementing.

Roof of Drive in North End of No. 6 Level, Eleanora Mine.



Reference.—A Jointed slate. B Slate traversed by net-work of quartz veins. C Slate breccia cemented with transparent and white quartz. D Felsite dyke filled with nodules. E E E Faults. F Antimony.

In the unoxidised ore the metallic minerals, besides gold, are sulphide of antimony, arsenical pyrites (white mundic), and a little bournonite (?).

In some of the reefs good gold is visible; especially is this the case in the Little Reef, where specimens occasionally turn up quite thick with coarse gold. The gold is often quite red, having the appearance of copper.

The steepness of the gorge slopes seems to prevent the accumulation of thick oxidised ore masses, as the heavy and frequent rains would sweep this softer material into the gully.

The reefs are often 12 to 18 inches thick. The Big Reef outcropped strongly on the surface, showing 4 feet width of stone. The Little Reef, however, is but a filament of quartz over long distances.

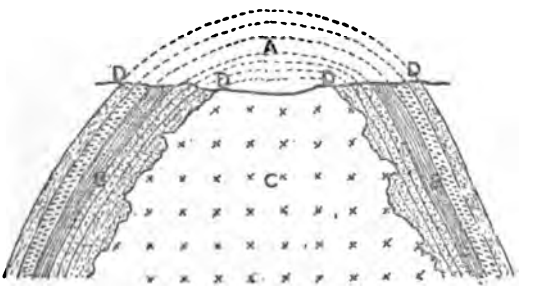
Besides gold, which ranks first in value among the mineral products of the field, antimony has been and is still, in a less degree, a source of profit. Of late the discovery of bodies of scheelite has opened up quite a field for the smaller miners and fossickers, as the coarse granite appears to contain innumerable small lodes of this mineral.

(*e*) Geological History subsequent to the Formation of the Lodes.

This is recorded principally in the wondrous amount of degradation that the rocks, once superior in position to the granite, have been subjected to. This area is a fine example of "earth sculpture" by epigene agents on disturbed slate and disturbing granite. The plain of accumulation, caused by carboniferous or older sediments, which had been laid down by the sea, was intruded and forced into folds by the great carboniferous (?) granite massif now forming the axis of the New England plateau. The exact amount of sediment eroded since this distant period is not known; but it must be enormous, since the Carboniferous or earlier formed strata, the highly inclined relics of which are greatly in evidence around the gold-field, are some thousands of feet in thickness.* A reference to the diagrams will illustrate this:—

Carboniferous (?) Slates, &c., horizontally bedded before Granitic Intrusion.

Carboniferous (?) slates, &c., folded by Granitic Intrusions.



A Original anticline removed by denudation. B Sedimentary rocks—Carboniferous (?) slates, &c., after granitic intrusion. C Granite massif. DDDD Present surface

* For particulars of this, see Professor T. W. E. David's description of New England in Gympie (?) times, in his Presidential Address to the Royal Society of New South Wales, 1894.

The right-hand side of this section, D′ D′, gives some idea of the appearance seen to-day in the district,† which is the eastern aspect of the great anticline. Clearly the portion represented by the dotted lines must have been carried away by epigene agents. And this has been done so effectually that the flowing contours of the present hills show to the untrained eye, no trace of degradation from a mountain system to a low plateau or plain. The river system of the ancient granite plateau was a fairly mature one, as the forces of erosion had reached that stage when the soft contours which mark the "death of the mountain" had succeeded to the peaks of circumdenudation, with the usual accompaniments of buttress and precipice that had resulted from the forces of erosion acting in the earlier stages on the Palæozoic slates.

Later in geological time, a great Tertiary basalt outburst flooded the Hillgrove and Metz area, filling the water-courses, and forming flats here and there. Previous to this event Baker's Creek and Gara River were united, and flowed where the town of Metz now stands. The basalt outflow diverted these streams into different channels. The waters now forming Baker's Creek attacked the highly inclined slate, and hollowed it out along the line of outcrop, thus carving out for themselves approximately meridional channels. The slates were rapidly eaten back, particularly in spots where, as at Swamp Creek, there was any resemblance to anticlinal structure, until the great east and west line of granite and slate junction was reached. The cuboidal jointing of the granite soon led to its degradation in turn, but not along the rapid lines that the slate had been attacked. This explains the appearance of the creeks to-day, with their deep gorges in the slate country, and precipitous and narrow ravines in the granite. The whole of the Baker's Creek ravine, as also that of Swamp Creek and Four-mile Creek has been eroded since Tertiary times—possibly Pliocene. (Plate IV, also plan.)

(*f*) Petrological Notes on some Hillgrove Rocks.

Both in macroscopic and microscopic examination the rocks of the Hillgrove area exhibit the influences of metamorphism. The ferromagnesian elements may be observed to pass into large masses of brownish or green material. They are rarely seen in a clear state, but are often replaced by viridite. The felspars are faulted in a remarkable manner, and are frequently kaolinised or replaced by epidote, secondary quartz, and secondary felspar. Much of the felspar being plagioclase, it alters in conjunction with the biotite to saussurite. The prevailing types of rock at Hillgrove belong to the granitites, although a red rock at Gara shows affinities with true granites. These granitites in places are of very basic variety. One or two types would, by some observers, be referred to the intermediate rocks. Mr. J. A. Watt, M.A., B.Sc* classes the eruptive rock containing the gold lodes at Wyalong as a very basic granite, showing great affinities with the quartz-mica diorites of some petrologists.

The holocrystalline rocks of acid composition in New South Wales will be found very frequently to belong to the granitites rather than to the true granites.

Slide 1,669.—Biotite granitite from main granitic mass, near Township.

Macroscopic Characters.—A dark holocrystalline rock, porphyritic, with large felspars, rectangular to sub-elliptical in outline. Decidedly gneissic in appearance.

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* Mineral Resources, No. 5, page 15.

† In reality, the strata were thrown into a series of folds, and were faulted in many places.

To face page 22

BAKER'S CREEK GORGE, LOOKING SOUTH FROM CAMPBELL'S SPUR.

Microscopic Characters.—This rock is full of plagioclase, orthoclase being poorly represented. There are two crops of felspar. The first crop consists of phenocrysts, as much as two inches in length, representing the intratelluric phase of crystallisation. Many of these crystals have edges so corroded as to have lost their original rectilinear outlines and to possess sub-elliptical contours. Some of the triclinic felspars belong to the potash variety known as microcline, having an appearance of plaited basket-work under crossed nicols. Albite and carlsbad types of twinning are observable at times in the same crystal. Schillerization occurs in certain crystals. The second crop of felspar consists mostly of small plagioclase crystals of glassy habit, twinned on the albite plan. Interpenetration twins and compound multiple-twinning not uncommon. Biotite and muscovite are both present. Some of the less decomposed of these polarise in high colours; the edges are frayed, and the crystals are often drawn out into long curvilinear lines. Decomposition products are present as viridite and saussurite. Quartz is present in fair quantity, also in secondary form; sometimes observable in the centre of plagioclase crystals. Scattered grains of a mineral possessing fairly high refractive index occur throughout the slide. Under crossed nicols the colours are dark blue to black. Apatite is present in quantity as rods and stout crystals. Magnetite also occurs. Lustre-mottling is also observable in this slide.

Slices from Rock Specimens 3,908, 3,913, 3,665.—Locality, Baker's Creek, near junction with Four-mile Creek. These rocks represent phases in the cooling of a very basic granite. They are much altered, and flow structure is not uncommon.

Macroscopic Characters.—Dark holocrystalline rock showing bronze-coloured micas, decomposed hornblendes and biotites.

Microscopic Examination.—The felspar is represented principally by plagioclase. Much of this is kaolinised, while a later crop of the same mineral is of lathlike and glassy habit. Beautiful examples of faulting occur in the felspars (Plate X), and in other crystals under crossed nicols, the alternate light and dark bands, due to multiple-twinning, are in curved lines as a result of crushing. The plagioclase in places is altered to epidote, as grains and irregular patches. Several crystals possess a thin outer-ring only of felspar, the centre being occupied by epidote. Individual crystals show twinning on both carlsbad and albite plans. Ferromagnesian minerals, as biotite and hornblende, are present in great quantity. Both are generally highly altered and the slides are full of viridite and a fair proportion of saussurite. Muscovite is also present. Primary quartz is a minor constituent. Secondary quartz is present. Apatite and magnetite are well represented.

This rock has a high specific gravity, and by some petrographers would be referred to the acid end of the diorite group.

Rock Specimen 3,911.—Granite from Gara River, five miles west of Hillgrove township.

In hand specimens this appears as a beautiful pink holocrystalline rock of medium coarseness. Strings of epidote occur throughout the rock.

Under the microscope the felspar is seen to consist of both triclinic and orthoclase varieties. Orthoclase is present in abundance, the crystals being quite cloudy through kaolinisation. Sections of plagioclase occur showing interpenetration twins. Both orthoclase and plagioclase are crossed by strings of epidote.

Much decomposed biotite is present. Quartz is greatly in evidence, the crystals being quite speckled by reason of numerous liquid and gaseous inclusions.

Apatite occurs in stout prisms and long needle-like forms. Iron pyrites is present in abundance.

Rock Specimen 3,999.—Fine-grained granite from Four-mile. Extremely altered, having appearance of fine-grained white sandstone in places. Biotite is present, but much altered, sheared and drawn out in threads by dynamic metamorphism. Felspar occurs as plagioclase and orthoclase, much kaolinised. There is a great development of secondary quartz. This rock belongs to the oldest granite of the field, and shows relationship with the granitic inclusions in the main mass.

Rock Specimen, 3,966, *Slide* 3,966.—Quartz-felspar porphyry from No. 3 level of the "Little Reef," Baker's Creek Mine. This appears in hand specimens as a fine-grained dark rock, porphyritic with white felspar crystals.

The microscopic examination of this rock reveals the influence of long continued metamorphism. The base is microcrystalline to cryptocrystalline, and exhibits "flow structure" in the vicinity of the porphyritic constituents. These latter consist of idiomorphs of plagioclase, representing the intratelluric stage of crystallisation. Interpenetration twins and cross-twinning are common. Zonal structure is noticeable in the plagioclase. The second crop of felspars is composed of stout squarish triclinic and orthoclase crystals.

The biotite is much altered in places to non-pleochroic brown and green products, and appears drawn out into wavy lines. Apatite and iron oxide are present.

Rock Specimen 3,967.—Felsite from dyke near Garibaldi Dam.

Cyptocrystalline base, with numerous small hexagonal and lozenge-shaped sections of transparent greenish-brown amphibole.* These crystals are of rod-like habit, and exhibit twinning. The mineral is pleochroic. Sections cut parallel to the plane of symmetry yield more brilliant colours under crossed nicols than those cut in the orthodiagonal zone.

Epidote, apatite, and magnetite present.

Rock Specimen 3,970.—Dyke in Swamp Creek. This rock is a felsite of much fresher appearance than the ordinary types of Hillgrove eruptive rocks. Micas are very plentiful, with well preserved edges and exhibiting brilliant polarisation colours.

Rock Specimen 3,971.—"Kicking" slate from No. 11 level, "Little Reef."

This rock possesses a remarkable curly structure, and contains veins of secondary quartz. Alteration products are present.

Notes on the so-called "Pebbles" of the Eleanora Dyke.

The dyke-rock belongs to the basic granitic type, and is much decomposed, the biotite being changed to viridite, and the plagioclase to saussurite.

Throughout the dyke, numerous pieces of a much decomposed and very basic rock occur, having the rounded contours characteristic of pebbles. In places where the dyke has bent slightly from a straight course, the included portions occur in such abundance as to resemble a conglomerate. These fragments fit into distinct sockets, and may be released, when they impress the uninitiated with their pebble-like habit.

They consist of ultrabasic material, much decomposed. Their specific gravity is 3, and the abundance of viridite present causes them to possess a greenish colour.

Very few similar occurrences have been notified in New South Wales.

Mr. J. E. Carne, F.G.S., Geological Surveyor, has described† a nodular felsite from Pambula. In this case, however, the nodules appear to be simply segregations of the felsite magma itself.

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* Both Mr. G. W. Card, A.R.S.M., and Mr. W. S. Woolnough, B.Sc., agree in referring this mineral to the amphiboles.

† Annual Report of the Department of Mines and Agriculture for 1896, page 111.

The Pennant Hills basalt quarry contains numerous rounded pieces of an ultrabasic rock, containing chromite or picotite, olivine and magnetite, and representing probably a variety of dunite. Professor T. W. E. David, of Sydney University, suggests that the basic magma in its upward progress caught up fragments of an ultrabasic rock, and subsequently corroded the fragments so caught up, till they presented the appearance of sub-ellipsoidal masses.

A similar origin may probably be assigned to the Eleanora "pebbles," but whereas in the Pennant Hills pipe the magma is basic (olivine-basalt), in the Hillgrove case the magma is an acid rock, or one belonging to the upper or acid end of the intermediate group. Mr. W. S. Woolnough, B.Sc., of Sydney University, suggests that, owing to the acid nature of the magma, there should exist a zone of intermediate composition between the nodules and the dyke matter proper.

Mr. E. F. Pittman, Government Geologist, mentions the occurrence at Lucknow of rounded masses of augite andesite at or near the junction of huge masses of andesite and serpentine. The augite andesite blocks are completely enveloped by the serpentine.

6. LIFE OF THE REEFS AT THE LOWER LEVELS.

(1.) Granite generally occurs as bosses, *i.e.*, more or less dome-shaped masses, with the broader portions as bases.

(2.) The granite bosses of Hillgrove have a very slight inclination from the vertical, as shown in diagrams elsewhere.

(3.) The fine-grained intrusive granite near the Sunlight Reef and the Baker's Creek properties appears to be almost vertical in slope.

(4.) The slate belt is excessively narrow where the gold occurs.

(5.) The granite almost abuts on some of the reef lines.

(6.) The *main* granitic mass of the field does not appear to cut off the lodes, and actually carries some, *e.g.*, the Eleanora and Freehold Reefs, continued into the granite. The Hopetoun, Starlight, Centennial, Carrington, and Cosmopolitan lodes are contained wholly in the granite.

(7.) The last and finest granite of the field appears only as a destroyer, and not a maker, of gold reefs, and cuts across the strike of the Little, Big, and Baalgammon lines of reef at a short distance from the creek.

It therefore seems useless to spend time and money in the exploitation of the country to the north-west of the Baker's Creek property. As to the Baker's Creek property lines of reef, dipping away as they do from the fine-grained granite, and towards the reef-forming granite mass to the north, it seems unnecessary to make any comment. A reference to the general section will illustrate their position with respect to the fine-grained granite mass.

The Sunlight varies in distance from 60 to 200 yards from the fine-grained granite, and dips towards it. A reference to the plan of the field will show its approximate parallelism of strike to that of the granite and slate junction close by. The granite, however, as observed in No. 5 tunnel, and at the surface, has very little inclination towards the reef, and therefore may not affect it for a great depth, except as a little crushing and by faulting, and this only at its eastern end.

The Eleanora appears to be derived from the main granitic mass close by, and no other igneous rock, except the dyke, is close at hand. It may also be noticed that only in the vicinity of the main granitic mass are the reefs

payable, none of the reefs being traced into or to the neighbourhood of the greenish granite to the south. It must be remembered that much of the granite to the south of the Sunlight is of the same character as that of the main mass, its exact line of junction with the greener rock not being ascertained.

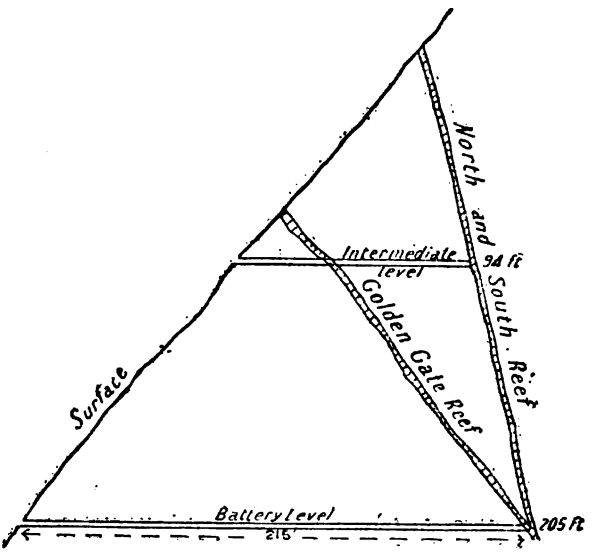
7. DESCRIPTIONS OF MINING PROPERTIES.

The order selected in this description of reefs and properties is not intended to be at all indicative of the proportionate value of the properties enumerated, *e.g.*, the most valuable block on the ground is that of Baker's Creek Company, which is described in the closing pages.

(*a*) The Golden Gate Reefs.

These reefs were worked first for antimony (?). Up till seven years since they were held by different parties, and eventually fell into W. Miller's hands. Thomas Snow, of Hillgrove, took them then on tribute from Miller, who resided at Armidale. It afterwards passed into the hands of the Australasian United Exploration Co. This was in February, 1897. At that date it was by them amalgamated into the Hillgrove Proprietary Mining Property, Ltd. In April, 1898, the Cooney Proprietary Co. amalgamated with the latter, and as such it remains. For this information I am indebted to Mr. H. M. Porter, Manager for the Cooney Proprietary Co.

Sketch illustrating method of working the "Golden Gate" and "North and South" Reefs.



Two reefs run through this property, viz., the Golden Gate Reef and the North and South Reef. The ore has been won from these by tunnels driven into them from the hill side. The strike is approximately N.-W., but it varies very much owing to numerous faultings and crushings. It underlays steeply to the east. The Golden Gate Reef itself underlays 35 feet in 100 feet vertical descent; in 205 feet it underlays 94 feet.

The Golden Gate and North and South Reefs intersect at a distance of 215 feet from the mouth of the tunnel, and 205 feet below the open cut of the North and South Reef. According to Mr. Thomas Snow, this carried 2 ounces of gold to the ton. Underhand stoping has been carried on for 40 feet below this level.

The new company did a little work here in September, 1897. A winze was sunk 197 feet 6 inches from the tunnel on the top into the North and South Reef to the bottom level of the Golden Gate.

At the intermediate level the cross course was driven on, and the south wall was stripped for a distance of 66 feet, but no reef was exposed. The Golden Gate Reef was lost for a time owing to the intersection of three or four cross courses.

Through the courtesy of Mr. Thomas Snow, formerly manager of this property, the following returns are published here. The crushings were performed on the spot with a 10-head battery.

From the east reef, known as the Golden Gate Reef, the top level yielded 1,000 oz. of gold for 1,500 tons of ore crushed.

From the lower level 600 tons were crushed for a yield of 900 oz. gold, and from the North and South Reef, 1,000 tons were crushed for 200 oz. of gold.

Total, 2,200 tons for 2,100 oz. of gold.

(*b*) The Proprietary's Claims.

These consist of various properties, viz., the lower and upper Cooney tunnels, the rise into Baker's Creek No. 3 level, and extension also of the same. (*Vide* diagram.)

The workings performed by the old Baker's Creek Co. are all connected by means of the main Cooney tunnel.

This fine tunnel starts from the northern boundary of M.T. 11, about 2 chains from Baker's Creek. Its course is straight and is N. 23° 18′ E. Up till 1st April it had been driven into the hill 2,054 feet. It is about 8 feet high and 8 feet wide. This was a portion of the property held by the late Baker's Creek South, which company abandoned the ground some years ago after driving some 300 feet into the hill. It then lay idle until a local syndicate, known as Baker's Creek No. 1 Extended, applied for a tunnel site to enable them to prospect the blocks lying to the south of the Baker's Creek Mine. This syndicate cut the tunnel down, making it wider, and extending it for a further distance of 100 feet. The total distance driven till then was 405 feet. Then the United Australian Exploration Co. purchased the ground held by the syndicate, and since that time the company have continuously extended the tunnel. It was proposed to drive the tunnel a distance of 2,000 feet into the hill and then pick up the Golden Gate Reefs.

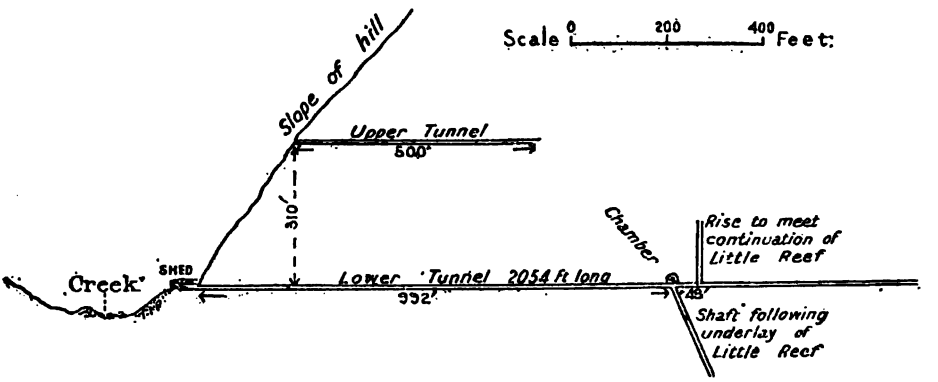
In driving the tunnel a number of veins had been cut, as many as seventeen different ones being struck between the 992 and 1,671 ft. marks. A shaft is being sunk on the first one met with, supposed to be the "Little" Reef. As five others have been cut close to it, it is doubtful which will be the prize—to wit, the "Little" Reef. This is at a distance of 992 feet from the mouth of the tunnel, where a chamber has been cut out to allow of hauling gear to be set up. The shaft is a main underlay one, and is being carried down at a uniform angle of 72° 30′. The system of timbering adopted is that known as the "Colorado"—usually employed in America. It consists of heavy timbers or main sets following the underlay, and all cross-pieces are set normally to the underlay also, so as to overcome side thrusts from the walls

The platforms in the ladder-way are also normal to the shaft walls, and ladders are attached to the footwall. This is also known as the "square-set" system.

At 1,040 feet from the entrance, a rise was put up 138 feet, and connected with the extension of No. 3 level of Baker's Creek workings along the "Little" Reef. This extension of No. 3 level consists of a zigzag system of crosscuts to pick up the southern continuation of the reef. It is very possible that the reef was lost all this time. (*Vide* diagram.)

The upper Cooney tunnel is in portion 182. It was driven 500 feet in a direction N. 44° E., and it lies 310 feet above the lower tunnel. It was driven by the Baker's Creek South Co. The present proprietors have driven 162 feet on a vein at a distance of 400 feet from the entrance. The diagram explains the relative positions of the workings.

Section across Proprietary tunnels. Both tunnels are projected into one plane. The direction of the Lower Tunnel is approximately at right angles to the strike of the "Little" Reef.



The Proprietary Company, being possessed of an enormous capital, are determined to save no expense in establishing a proper mining plant on the field. An air compressor is in use which, by compressing air to the extent of 80 lb. to the square inch, and working at 80 lb. pressure, can keep six to eight rock drills at work. The air is conveyed down the gorge by a straight cast-iron pipe, 5 inches in diameter, 2,308 feet in length to the mouth of the tunnel, and 2,000 feet along the tunnel itself. The difference of altitude between the engine and tunnel is 1,500 feet. The piping on the hillside (2,308 feet long) is provided with eight expansion pieces, each of which working on a sleeve is allowed a slide of 17 inches. The gorge is subject to extreme variations in temperature. An extreme movement of 7 inches has been noted on one sleeve. Six rock drills are used by the Company; three "Nationals," two "Ingersolls," and one "Little Giant." With a "National," one hole 5 inches deep was bored in twenty-two minutes in the slate. It may be noted in passing that certain bands in the slate of this field are extremely difficult to pierce. A banded, dark black, or a curly grey slate gives the most trouble. According to Mr. H. M. Porter, some of it nearly approaches the topaz rock of the Emmaville emerald mines in hardness. Of the machine drills, the National is probably the most serviceable on the field. The Ingersoll appears to work a little more speedily, but the

chuck attachment for holding the drills is not so good, too much time being occupied in changing the drills, and this part of the machine is frequently in need of repair.

Shots are being fired simultaneously by electricity, although the occurrence of stray defective fulminating caps causes annoyance. The Company intends laying a tramline down the hillside at an early date.

(*c*) The Hopetoun Reefs.

The property containing these reefs was taken up by a company of 100,000 £1 shares. It was known at first as the "Root Hog." Afterwards, various names, such as the Earl of Hopetoun and Lady Hopetoun, were given to different portions of the property. At present all the blocks constituting the old gold leases have been amalgamated into one property—The New England Scheelite Property.

The workings on the reefs are confined solely to the coarse granite area. The reefs approximate closely in both strike and dip to the more important lodes of the Hillgrove Gold-field. Of recent years the gold of the reefs has been found to give place, in patches, to masses of scheelite. In the upper portions of Nos. 1 and 2 lodes the scheelite was of very good quality. Mr. Fuller, of Hillgrove, informs me that at a depth of 300 feet below the surface a large body of low-grade lime tungstate has been exposed, in places as much as 3 feet wide.

Both gold and scheelite have been won by means of tunnels driven into the hillside.

No. 1 tunnel, 20 feet above the creek, bears 15° north of west and is 1,176 feet long. About 400 feet from the mouth of the tunnel No. 2 reef was cut. This has a strike of 35° north of west, and is thrown some 5 feet to the south by a cross course near the point of intersection with the tunnel.

A little further along Nos. 1 and 2 reefs have been stoped for a width of 20 feet, a height of about 50 feet, and a length of 60 feet. In the chamber so formed machinery was set up for the sinking of a main underlay shaft. At a depth of 30 feet the sinking was abandoned. No. 2 tunnel, 110 feet above the creek, cuts No. 2 reef some 50 feet from its mouth. The bearing of the reef here is 36° north of west. Here, also, a cross course has thrown the reef some 6 feet to the south.

No. 3 tunnel is driven on Nos. 1 and 2 lodes at a height of 170 feet above the creek bed. No. 4 tunnel is also driven on these lodes at a height of 220 feet above the creek.

Another vein, known as No. 3 lode, lies a little to the south of Nos. 1 and 2 lodes. Nos. 2 and 3 reefs are 15 feet apart in No. 2 level. The general dip of the reefs is north-east at 80°.

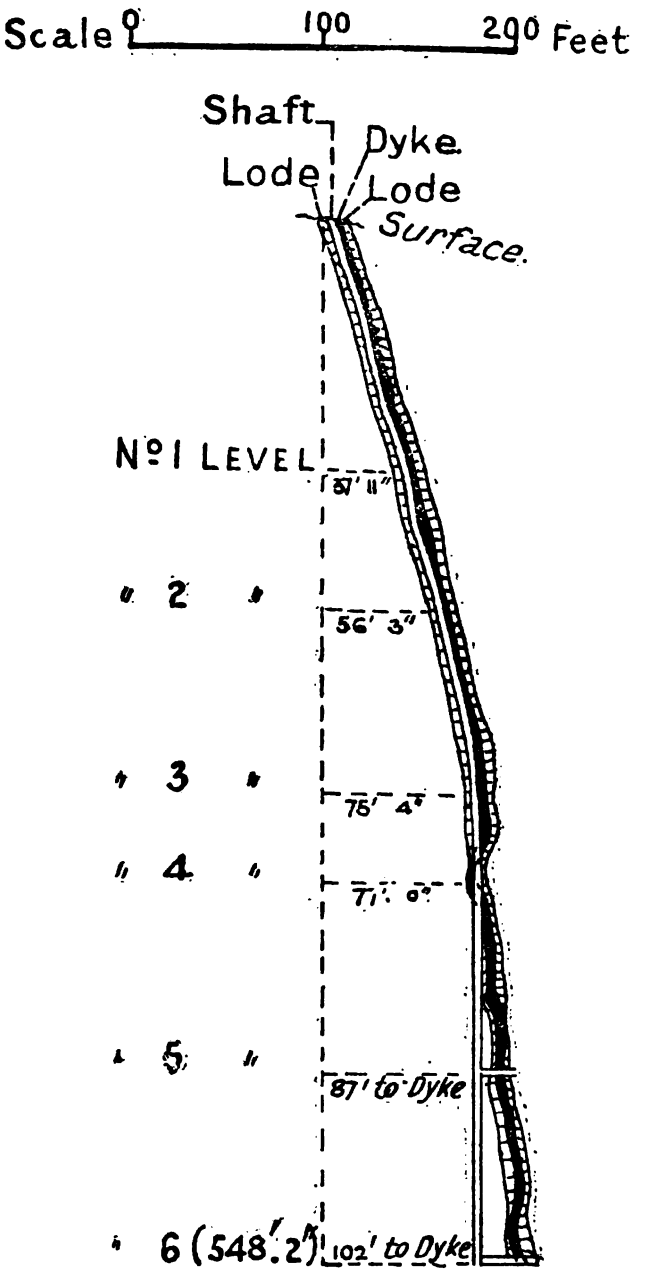
The early gold returns of this mine were supplied by Mr. S. Sullings, of Hillgrove.

The first four crushings yielded respectively 500, 400, 300, and 200 oz. of smelted gold.

(*d*) The Eleanora Reef.

The history of this mine has been outlined in the earlier pages of the report. Messrs. Brackin, Daly, and Elliot, having found the Eleanora in 1878, put in a claim for the Government reward offered for discovery of a payable mineral lode. At that time it was believed to contain antimony only. Reconstruction has been resorted to several times. The returns since 1890 show when reconstruction has taken place since that date.

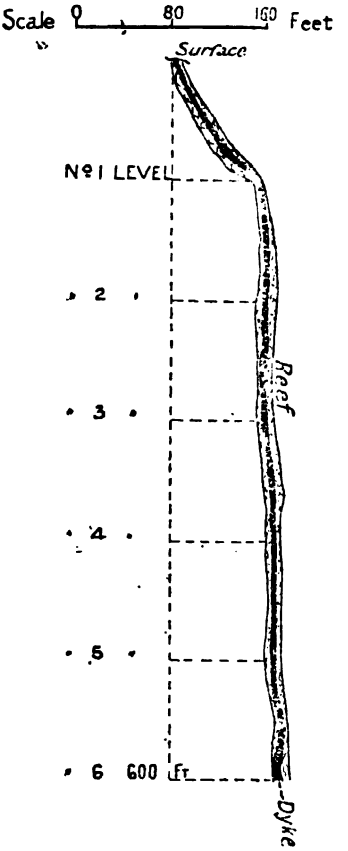
Section across lode, dyke, and shaft in southern (shaft) end of Eleanora Mine.



Between No. 6 and No. 5 levels and between No. 5 and No. 4 levels the dyke is bent, and the lode appears to sit on the bulged-out portion.

The Eleanora Reef, as also its southern extension, known as the Garibaldi, runs for the greater part of its length along the flat land at the top of the Baker's Creek gorge. It is the only important line of reef in the area that practically lies above the gully. Towards its northern end it runs diagonally along the face of the gorge till it passes into the coarse granite. Southwards it is continued over the point of the Garibaldi Spur, but does not appear to last as far as the greenish granite mass lying in that direction. Its strike is north-west and south-east approximately, and it possesses an underlay of

Section across Eleanora Reef towards Northern Boundary.



A brecciated slate lode, with white or transparent quartz cementing, heavily charged with arsenical pyrites, and containing vughs full of beautiful stibnite crystals. It is a huge low grade ore, as much as 23 feet wide in places. A metamorphosed granitic dyke occupies the central portion of the lode.

about 1 in 5 towards the north-east. If the Cosmopolitan Reefs are simply continuations of the Eleanora Reef, as appears probable, not only from their line of strike, &c., but quality of stone, as far as antimony is concerned, then this line of reef stands proven over one and a half miles of country. A granitic dyke, much altered, follows the lode along the greater part of its course, occupying the central portion of the lode.

The country traversed is, for the most part, a slate, altered into a knotted schist. Numerous vughs occur throughout the lode, filled in places with magnificent stibnite crystals.

The returns show this reef to be a huge low-grade ore deposit. In places the stone is, with the included dyke, 22 feet wide. (*Vide* sketch of reef on page 20)

At first tunnels were driven on the lode from the side of the gorge. No. 4 is the lowest tunnel so driven. On the lip of the fall a whip-shaft was sunk on the reef. Afterwards the north shaft was put down to No. 4 level. This is an underlay shaft, and necessarily, as will be seen from sections of the lode, involves great strain on the hauling ropes. A south shaft was afterwards sunk, 200 yards from the north one, and at the No. 4 level both shafts were connected by a zigzag drive, which was generally carried along the reef. At the southern shaft the reef has been worked on both sides of the dyke, here about 4 feet wide. At times the total width of reef and dyke at this level is 10 feet. These shafts were then sunk vertically to No. 6 level. The south shaft is being carried down another 100 feet.* A reference to the vertical section of the Eleanora will show the amount of stoping performed in this mine (Plate XI).

No gold returns were obtained before June, 1892, but since that date they are as follows :—

Date.	Tons crushed.	Smelted Gold. oz.	dwt.	grs.	Antimony, &c.
July to 31st December, 1892.....	2,595	1,998	13	15	77½ tons crude antimony. 13¼ tons metal antimony.
January to 30th June, 1893	3,006	1,638	9	12	157 tons crude antimony.
July to 30th December, 1893.....	3,095	1,524	12	0	212 tons crude antimony.
January to 30th June, 1894.....	3,152	1,133	0	0	227 tons crude antimony. 86 tons concentrates.
July to 30th December, 1894.....	6,093	2,261	5	0	213 tons crude antimony. $88\frac{1}{20}$ tons concentrates.
January to 30th June, 1895...	5,897	879	6	0	979 tons crude antimony. 37 tons metal antimony. 134 tons concentrates.
July to 30th December, 1895.....	6,305	2,010	6	0	$186\frac{1}{2}$ tons concentrates.
January to 30th June, 1896..... .	6,606	3,359	18	0	$96\frac{1}{2}$ tons crude antimony. $9\frac{7}{20}$ tons metal antimony. 231 tons concentrates.
July to 30th December, 1896.....	6,847	4,696	7	0	$211\frac{1}{5}$ tons concentrates.
January to 30th June, 1897.....	6,230	2,596	7	0	$9\frac{1}{5}$ tons crude antimony. $11\frac{3}{20}$ tons metal antimony. 278 tons concentrates.
July to 30th December, 1897..... ..	6,180	2,826	1	0	298 tons concentrates.
January to 30th June, 1898..	1,879½	834	11	0	$5\frac{9}{20}$ tons crude antimony. $13\frac{3}{10}$ tons metal antimony. 138 tons concentrates.
July to 30th December, 1898.....	6,260¼	2,674	8	0	$3\frac{3}{20}$ tons crude antimony. $1\frac{3}{20}$ tons metal antimony. 230 tons concentrates.
January to December, 1899.....	220 10,195	104 2,939	11 16	0 0	270 tons concentrates. 14½ tons oxidised antimony.

* The Eleanora has since been shut down.

The calcined concentrates yielded on an average 3 oz. 10 dwt. per ton, with a value of £3 10s. per oz.

The antimony oxide brought £16 10s. per ton on the field.

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ELEANORA PLANT AND DAM, FROM THE EAST.

Machinery.—The Eleanora workings supply a 70-head battery. A tramline some 200 or 300 yards in length (Plate V) connects the north shaft with the battery. The average weight of the stamps is 760 lb., with a drop of 9 inches, and an average working speed of eighty-five drops per minute. The method hitherto adopted has been to pass the crushed material over blankets, but copper plates are very shortly to be substituted. At present the battery contains 2,110 square feet of blankets and only 30 feet of copper plates. Nine "Berdans" are used for amalgamating. There are also two Arastras, and thirteen Frue vanners. The crushing efficiency of each stamp is 23 cwt. daily. The amount of calcined concentrates produced per day is 1½ ton. About 200 men are employed in this mine.

(*e*) The Garibaldi Property.

This line of reef is the south-east extension of the Eleanora or Isabella line of reef. As with the Eleanora, it was first worked for antimony and afterwards for gold.

In places two reefs, or two branches of the one reef, appear to have been worked. These lines are 20 feet apart. Two vertical shafts have been sunk, of which No. 2 shaft is 240 feet deep. From the shafts the lodes have been worked by crosscutting. There are three levels, viz., the 100, 140, and 240 feet levels.

The 100-foot level on one line of reef west of shaft has been driven 90 feet, and to the east has been taken 100 feet. The direction of this level is 5° south of east.

The 140-foot level is 190 feet in length, and is almost directly under the 100-foot level.

The 240-foot level has been reached by crosscutting 50 feet from the shaft. According to the plan of the workings the two reefs met with at the surface make into one at the 140-foot level.

The sections across the Eleanora Reef will answer equally well for the general features of the Garibaldi Lode, the dyke accompanying the central portion of the lode.

Twenty head of stamps were used in crushing the ore.

(*f*) The Cosmopolitan Reefs.

This property was originally taken up as the North and South Cosmopolitans. It consists of two reefs trending in a north-west direction and cut across by an east and west gully, which divides the North from the South Cosmopolitan. The reefs lie wholly in the coarse granite (granitite) of the field, and are held by the miners to be the northern continuation of the Eleanora Lode. There seems much to favour this idea, since sighting along the strike of the Eleanora as it makes down the gully, brings the hairline of the compass in line with the direction of the Cosmopolitan tunnels. The lode, however, has not been proved along the whole of this distance, an unproven patch of several hundred yards in length occurring to the south of the South Cosmopolitan. The talus of the hill slope may simply have obscured any possible outcrop however.

These lodes were pegged out in the same year as the Baker's Creek Reefs, and, though originally worked for gold, were subsequently exploited for antimony. The workings consist of several tunnels driven into the hill on the reef. These tunnels are 100 feet below each other. The lowest is 70 yards

in length, driven in a north-west direction. The one immediately above is some 50 yards long, also driven in a north-west direction. The ore was brought to the tunnel-mouths and carried by tram up the sides of the hill. The underlay is to the north-east.

The South Cosmopolitans consist of tunnels driven in more than 100 feet into the hill. A heave has thrown one of these reefs 12 feet.

Many large parcels of antimony have been sent from this mine, one yielding 100 tons of metal.

From the Old and New Cosmopolitan Companies gold was obtained to the value of £31. From the "Old Cosmopolitan" £547 worth of antimony was extracted, and from the "New Cosmopolitan" £350 worth of the same metal was obtained.

(*g*) Carrington Line of Reef.

This is also thought by some to lie on the Eleanora line of reef, between the latter and the Cosmopolitans. The reef lies wholly in the coarse granite, and has produced much gold and antimony. Tunnels have been driven on the reefs. Formerly a large battery was in full working order on this side, while a fine dam for the conservation of water was constructed on the top of the falls 800 feet above the mine.

In 1886 this property was prospected by Mr. Thomas Snow, of Hillgrove. Tributors last year crushed 15 tons of stone for 31 ounces of gold.

(*h*) The Sunlight Reef.

The surface line of this reef is bold, and runs diagonally across the west side of the Baker's Creek gorge. (Plate VI.) The open cut is some 400 to 500 feet directly above the battery, while towards the West Sunlight it is 700 feet above the bed of the creek.

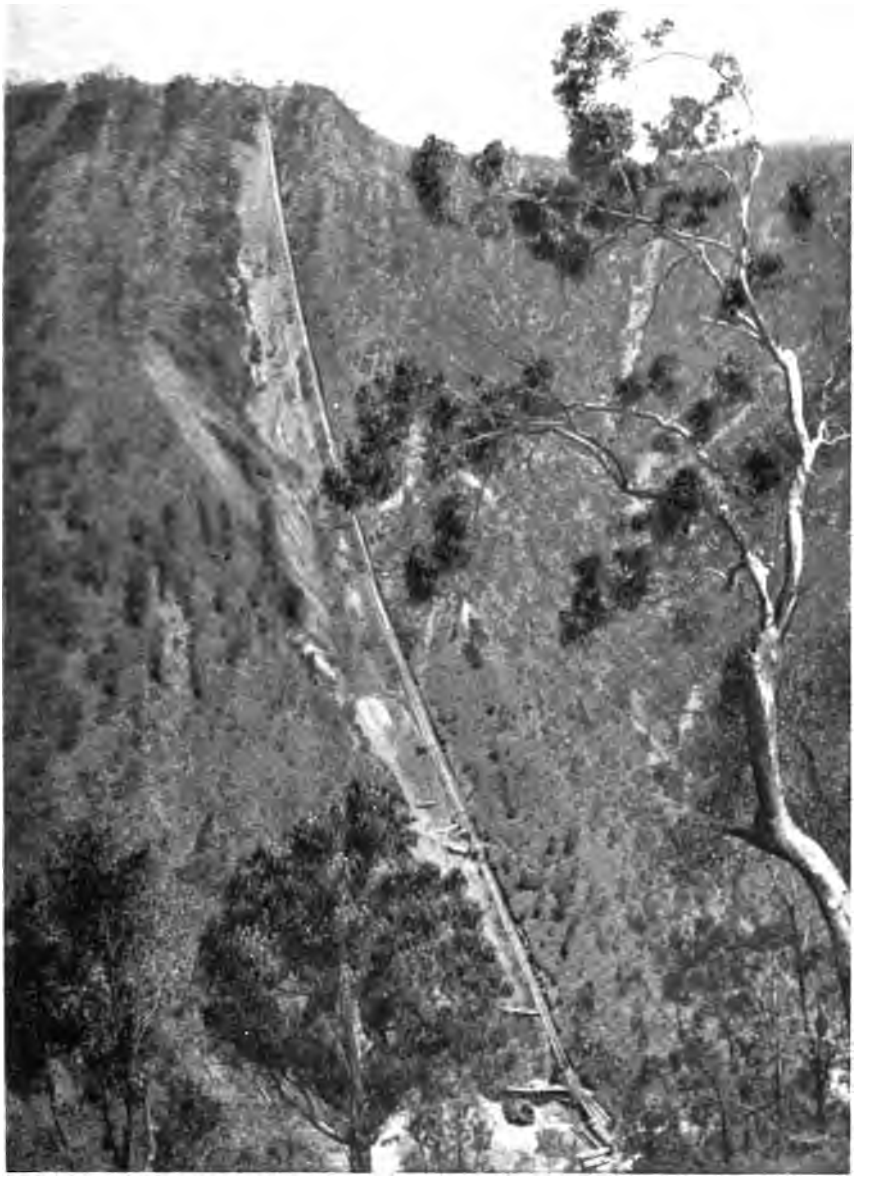
This property was first taken up by Moore, Speare, and Company about the year 1878 for antimony. Since that time the property has passed into various hands.

The general direction of the lode is 25° north of west. It runs fairly parallel to the outcrop of the latest granitic intrusion. The country is of slate and schist, much contorted and broken up by crushings and series of small faultings. The dip is about 1 in 5 in an easterly direction. The walls are better defined here than in the other reefs of the field. Magnificent crystals of stibnite (antimony sulphide) are found in vughs. From the surface to the No. 5 level the exploitation of the mine was carried on by means of short tunnels driven in from the hillsides. As the underlay is toward the creek, and the sides of the gorge are very steep, this method of winning the ore was comparatively easy.

No. 5 tunnel was driven in about 30 feet above the bed of the creek, and cut the reef 411 feet in the hill. No. 4 tunnel caught the reef at 240 feet, No. 3 at 70 feet, while the higher ones had tunnels driven on the lodes.

Short shafts were also sunk from the surface into the different levels.

On the No. 5 level the lode was worked east and west of the point at which the tunnel cut the reef. 500 feet along the lode in the western extension an underlay shaft was sunk, and from this Nos. 6, 7, and 8 levels are worked. The latter level is about 250 feet below the creek bed. The vertical section supplied shows the method of working the reef, and also the proximity of the granite along No. 5 tunnel. It must be remembered, however, that the large gold shoot of the reef is at some distance from the granite.



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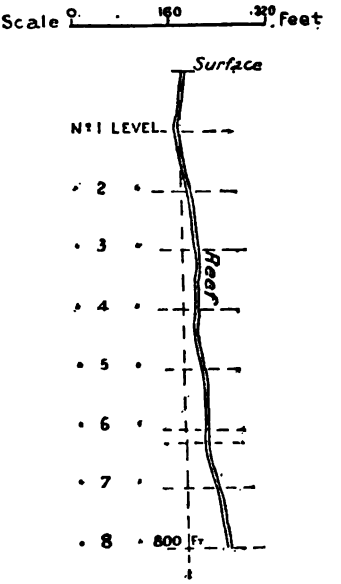
SUNLIGHT TRAMWAY, SEEN FROM THE COONEY TUNNEL.

No plan is supplied of the stopings of this mine, but it may be interesting to know that most of the reef has been won in the western end as far down as the 7th level (800 feet). The stone has been much crushed in this lode, and huge masses continually threaten to fall during the progress of overhand stoping. From No. 7 to No. 6 level the reef is being won by stoping in a diagonal direction.

Sunlight Reef.—Section at western end.



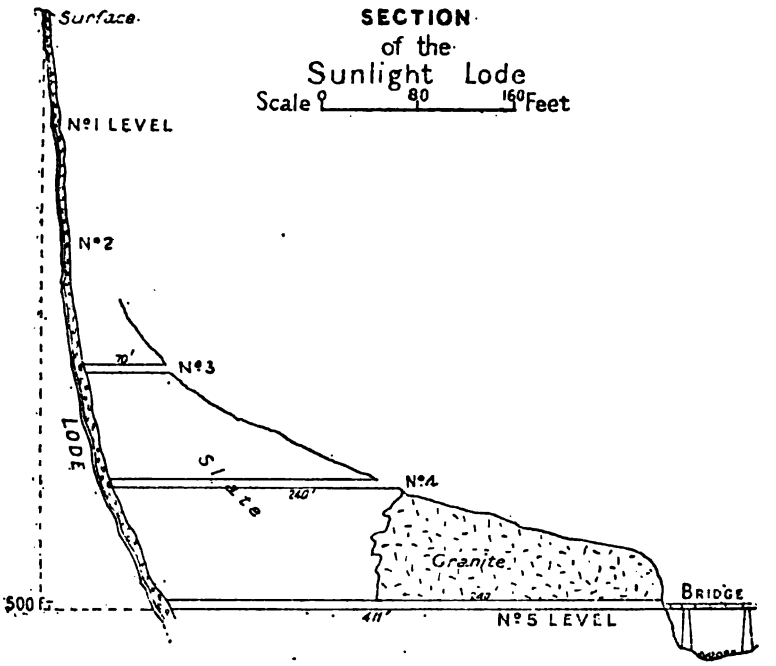
Down to No. 5 level the ore has been won by tunnels and a series of short shafts on the hillside. 950 feet along the No. 5 tunnel and drive an underlay shaft has been sunk on the lode.

At the eastern end the lode has been much faulted, but no trouble has been exercised to pick it up, as the stone is of inferior quality. Still, much of the reef has been extracted as low down as No. 5 level. In all, five shoots of stone are said to exist in the mine, each of which is more or less vertical.

No returns of the Sunlight Mine were available before 1892. From that date onward they are as follows :—

Date.	Tons crushed.	Ounces Smelted Gold.
		oz. dwt. grs.
1892 }	7,820	4,029 1 0
1893 }		667 10 0
January to December 30th, 1894 (partial return)	3,459	1,337 3 0
January to December 30th—		
1895	10,688	4,838 12 0
1896	13,248	7,927 12 0
1897	11,248	5,326 12 0
1898	10,997	4,598 9 0
1899	9,567	4,722 5 0

Sunlight Lode.



The lode is quartz and slate breccia, containing much antimony and arsenical pyrites. The lode has been reopened, and the later fissure filled with crushed slate. This disturbance seems traceable to the intrusion of the fine granite at A. The proximity of the granite to the lode will at once be observed. The plan represents the projection of the tunnels on to one vertical plane.

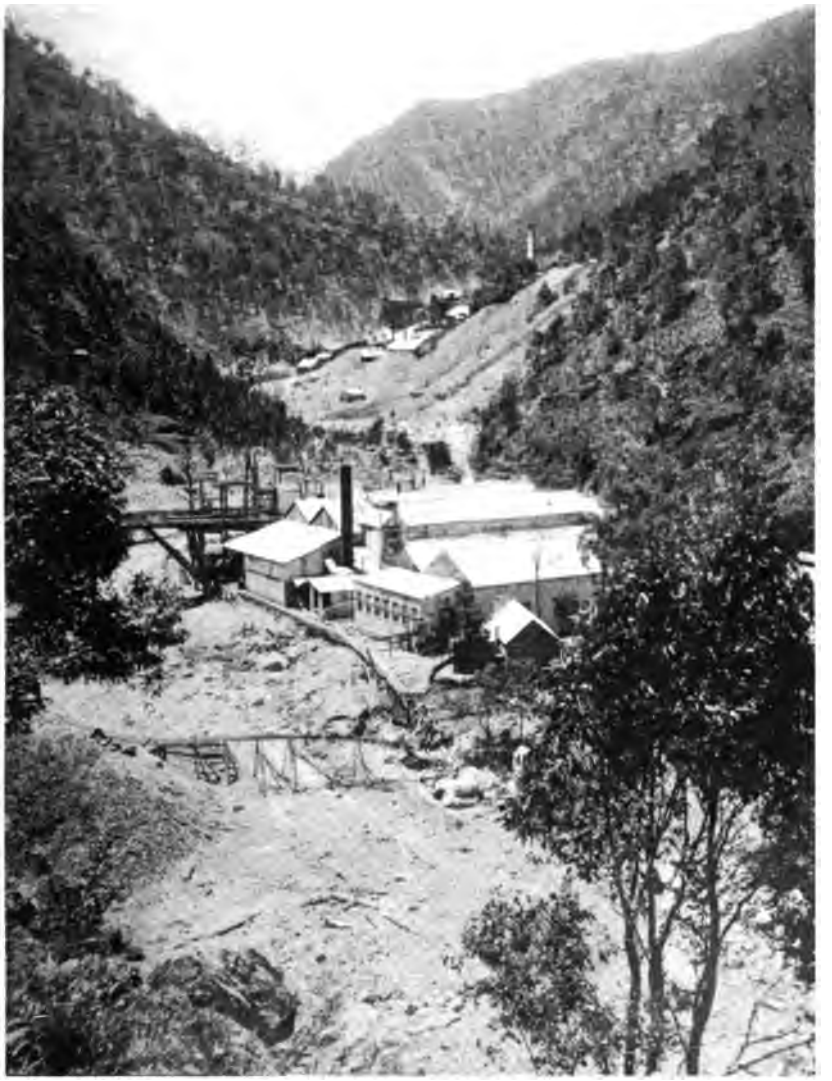
Total amount of quartz crushed from 1st January, 1892, to 30th December, 1899, is 75,085 tons for a yield of 36,873 oz. 6 dwt. 12 grs. of smelted gold.

The machinery consists of forty head of stampers, each averaging some 650 lbs. in weight. These, with a fall of 8 inches, working up to seventy-five blows per minute, assisted by a Blake-Marsden type of rock-breaker, and with automatic feeders, gives a result of 430 to 500 tons crushed per fortnight, or an average working efficiency for each stamp of 18 to 20 cwt. per day. The crushed ore passes from the stampers over 16 feet of copper plates, and the thick pulp from the settling boxes is placed on Frue vanners, each of which is served by five head of stamps.

The mine is lighted by electricity, and the lower levels of the mine were also, until very recently, worked by an electric plant stationed at the top of the main shaft in No. 5 level.

(*i*) West Sunlight Mine.

The work done by this Company consists in the exploitation of the north-west continuation of the Sunlight line of reef. Two reefs were worked, the Magazine and the West Sunlight or Main Reef. The strike of the reef at the boundary between the Sunlight and West Sunlight properties is 20° north of west, and the lode has been proved for 800 feet in this direction. Traces of it exist in the rough country to the north-west, but no payable prospects have been obtained.



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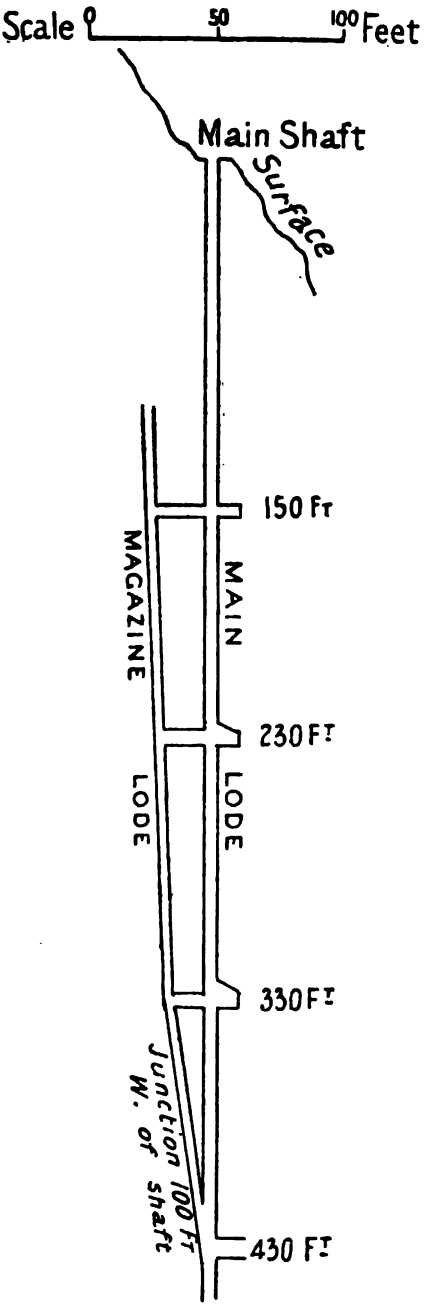
SUNLIGHT BATTERY, WITH CONSOLS AND BAKER'S CREEK WORKINGS IN THE MIDDLE GROUND.

Section across Magazine and Main Lodes of the West Sunlight Property, showing the bifurcation of main lode at 430-foot level, and the method of winning the ore from the Magazine lode.



The Magazine and Main Reefs were worked simultaneously from a main shaft, crosscuts being driven from the main line to work the Magazine Reef. At the 430-foot level the two reefs made into one. In all ten levels have been driven. No complete plan of the workings was obtainable. The cross-section shows the relative position of the two reefs, and the methods adopted for winning the ore. A good deal of stoping has been done, particularly between the surface and No. 5 level. Mining operations have been at a standstill during the past half-year (July to December, 1899). McNamara and Party expect to resume work early this year.

The following gold returns of the mine between January, 1894, and June, 1899, were supplied by Mr. McNamara, of Metz:—

Date.	Tons crushed.	Ounces Smelted Gold.	
		oz.	dwt.
January to June, 1894	4,614	2,546	19
July to December, 1894	4,943	2,479	13
January to June, 1895	3,792	1,659	10
October to December, 1895*	2,064	795	16
January to June, 1896	3,621	1,541	6
July to December, 1896	3,949	2,019	8
January to June, 1897	3,419	1,660	18
July to December, 1897	3,773	2,441	3
January to June, 1898	4,646	1,900	12
July to December, 1898	3,835	1,204	19
January to June, 1899	2,082	750	7

* Mine closed July to October, 1895, owing to want of water.

In 1898, 119 tons 13 cwt. of concentrates were treated for 583 oz. 12 dwt. of gold. Twenty head of stampers were in use, each stamper weighing about 900 lb.

(*j*) Baker's Creek Reefs.

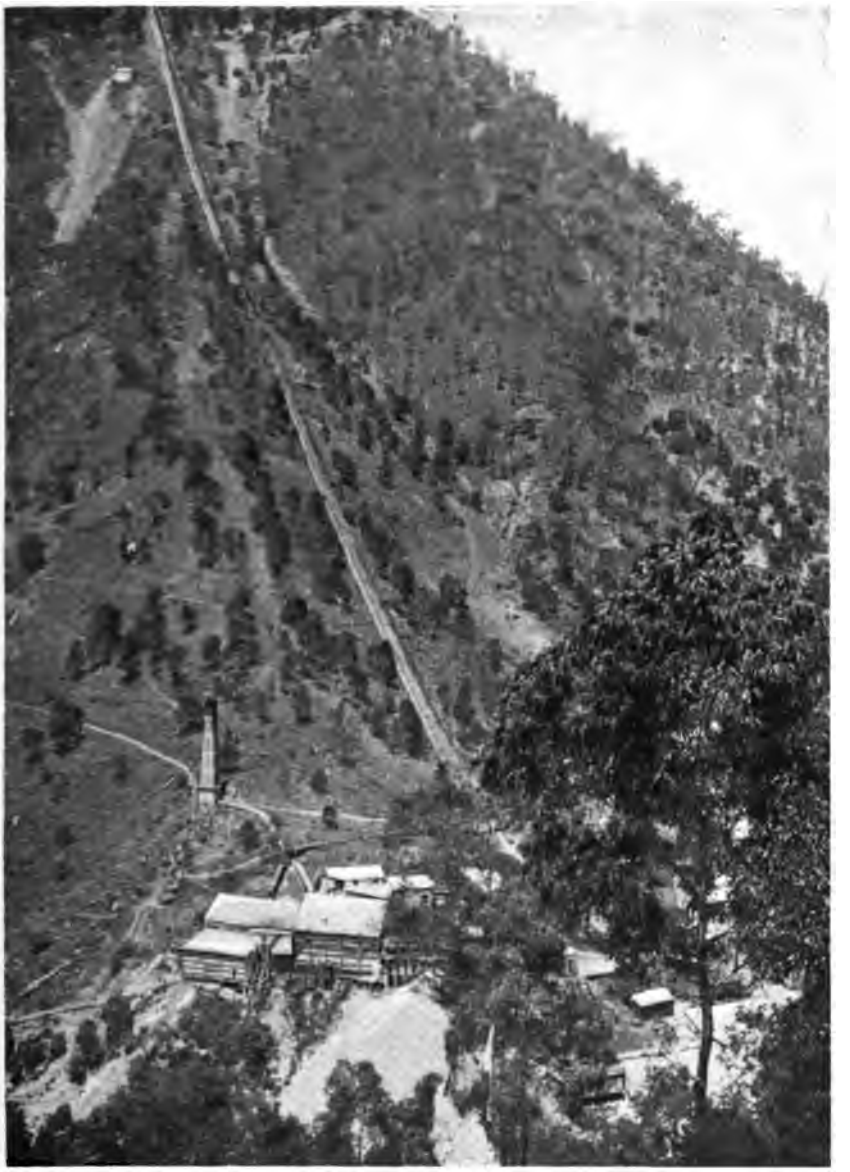
Baker's Creek property includes the most valuable portions of the Little Reef, the Big Reef, the Middle Reef, and Hill's Reef. These are situate in the lower portion of the eastern side of the gorge. By a mere accident the Little Reef was included in the area pegged out for the Big Reef, and as it underlay into the portion, the wealth of the property was assured. Since the initiation of mining operations on this property the Company holding it have regularly paid dividends.

The general trends of the reefs are as follows:—

The Little Reef	N. 55° W.	
The Big Reef	N. 50° W.	All dip easterly
Hill's Reef	N. 30° W.	at about 75.°
The Middle Reef	N. 65° W.	

The Big Reef outcropped strongly in one or two places at the surface, showing a body of stone 4 feet wide. But for some distance down it contained very little gold, and much of it in the higher levels was never stoped.

The Little Reef is marked in places by its thread or "stringer"-like appearance, and its lack of well-defined walls. The payable part of the lode in the Little Reef is confined to a steep shoot of stone. According to the underground managers, this has been worked from the No. 3 level to the lowest point yet attained in the mine, viz., the 13th level. In a straight line No. 1 cross-course is about 120 feet distant from the main shaft, while No. 2 cross-course is generally some 200 feet nearer the southern boundary. The



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BAKER'S CREEK TRAMWAY, FROM PETERSEN'S SHAFT.

north-west boundary of the shoot is close to No. 1 cross-course. The best gold in the upper levels was contained between the two cross-courses. At No. 7 level the gold was found thickly scattered about in No. 1 cross course; thence downwards it was obtained further to the south, and the shoot possessed a steep angle of dip. At No. 9 level the southern extension of the shoot was 53 feet from the end of the drive, 112 feet from No. 2 cross-course, and 418 feet from No. 1 cross-course. The shoot at this level was 40 feet wide.

At No. 10 level the southern boundary of the shoot was 40 feet from the end of the drive (more than 60 feet from boundary). The shoot itself was 40 feet wide, and was 163 feet from No. 2 cross-course.

Similar results were obtained in Nos. 11 and 12 levels. At No. 12 the southern boundary of the shoot was 90 feet from the southern boundary of the property.

The ore was won in the early days of the field by open cuts along the outcrops of the reefs. Good work was hampered considerably by the amount of surface debris (*see* longitudinal section, Plates XII and XIII), which at times amounted to as much as 50 feet in thickness. No. 4 tunnel was driven in on the reef near the bed of the creek. At the mouth of No. 3 level, a main shaft was sunk, and from this most of the reef has been worked. The shaft follows the reef to No. 6 level, and thence to No. 13 the ore has been won by cross-cutting from the shaft, which latter, though not vertical, does not follow the reef. The Big Reef has been worked below No. 3 level by cross-cutting from the corresponding levels on the Little Reef, on No. 1 cross-course. (*See* section across Big and Little Reefs, Plate XIV).

A shaft was put down to the north of the main one (at the entrance to No. 3 level), and levels at 125 and 225 feet respectively were driven along the Little Reef. The 225 feet level is nearly on a level with No. 6 in the main workings.

One of the difficulties in working the Little Reef is the apparent insignificance of the vein. Frequently it traverses the dense blue slate country as a mere ribbon, and unremunerative veins setting out from it frequently make into strong reefs up to 12 inches or 18 inches wide. Another is the difficulty attendant on working the "kicking" ground along certain levels. Certain parts of the reef, notably at No. 11 level, are unstoped, as the risk to the men's lives working the ground is considered too great to continue the work.

A tramway has been laid down from the top to within 50 feet of the bottom of the gorge (Plate VIII). Its course is perfectly straight, and the line itself is triple, with a central loop. Sleepers are fitted into the slope of the hill some 2 feet apart. The length of the line is 2,660 feet; the vertical descent is 1,407 feet, and the steepest angle of slope 43 degrees. An endless rope, $\frac{7}{8}$-inch in diameter, and 3,000 feet long, is in use for hauling the trucks. Its breaking strain is 22 tons, and its usual load, including the truck, never exceeds two tons. Formerly the men were compelled to walk up and down the hill-side to their work, but for some years past now the trucks have been utilised partly for this purpose. The men subscribe a certain proportion of their wages to an accident fund, and in case of a mishap, the injured ones receive attendance at the local hospital, and certain pecuniary assistance while incapacitated for work.

Machinery.—The company owns a fairly complete plant for crushing ore. The battery consists of 40 head of stampers, each averaging some 6 cwt., and having a fall of 6 or 7 inches. Their working speed is ninety to ninety-five blows per minute. Automatic feeders are in use, but the ore is broken up small enough in the stopes to dispense with a rock-breaker. Each stamper serves 7 feet of copper plates, and 20 feet of blankets per medium of slotted

screens; four Woodbury vanners and two large Berdan pans, each 4 feet in diameter, save the concentrates. About 500 tons of stone are put through every fortnight, each stamp thus possessing a working efficiency of 18 cwt. per day. The shoes of the stampers, as well as other rough ironwork, are cast on the premises.

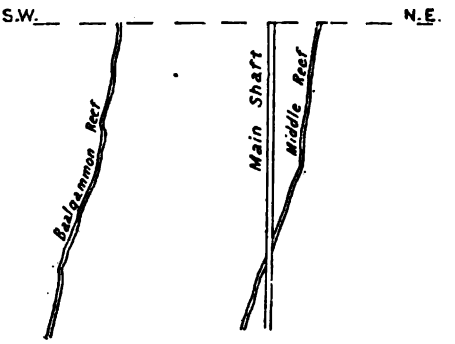
The following are the returns for the Baker's Creek Mine, with a few exceptions, from 1887, the year of discovery, up till the present:—

Date.	Tons of stone crushed.	Ounces of smelted gold.
		oz. dwt.
November 12th—December 24th, 1887	63	700 0
May 9th—December 27th, 1888	766	8,959 0
January 21st—June 29th, 1889	1,307	17,293 0
January 31st—June 28th, 1890	2,613	5,836 10
July 7th—December 31st, 1890	3,111	5,639 0
January 30th—June 30th, 1891	3,005	7,575 16
July 17th—December 24th, 1891...	3,121	10,500 0
February 26th—June 30th, 1892...	3,996	6,975 0
July 15th—December 23rd, 1892...	4,551	11,564 8
January 24th—June 30th, 1893	4,779	9,748 12
July 15th—December 23rd, 1893..	4,958	10,337 12
January 18th—July 10th, 1894	5,251	8,675 16
July 14th—December 23rd, 1894	5,677	8,918 12
January 26th—June 29th, 1895	6,710	8,194 2
July 13th—December 24th, 1895...	7,048	7,610 11
January 25th—June 30th, 1896	7,741	7,238 18
July 10th—December 30th, 1896..	5,354	5,278 13
July 23rd—December 24th, 1897...	6,809	5,933 10
January 21st—June 30th, 1898	6,563	5,131 15
July 29th—December 24th, 1898...	5,977	4,910 6
January 30th—June 30th, 1899	6,818½	6,642 0
July 1st—December 30th, 1899	6,368	6,474 13

(*k*) The Consols Reefs.

The reefs worked by the company owning this property are portions of the Little, Middle, and Baalgammon Reefs (Plate IX). The outcrop of the Middle

Section across Consols Property.



reef lies on the eastern side of the creek bed. Its strike varies from 20° to 25° east of south. It intersects the Little Reef immediately beneath the Baker's Creek assay office.

Plate IX.

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CONSOLS MACHINERY AND MINE.

The diagram represents a section across the Middle and Baalgammon Reefs on the Hillgrove side of the creek. Since September last, the company have sunk the main shaft vertically from the 200 to the 300 feet level. After driving for a short distance on the Little Reef, below and beyond the creek bed, and cross cutting in a westerly direction, a fine-grained granite was met with, in which the reef died away in so-called "stringers," or ribbons of quartz. The north west extension of the Little Reef is not so productive as the portion worked by the Baker's Creek Company. The Middle Reef yields the best stone.

Since September, 1897, this mine has yielded 3,550 oz. 12 dwt. of smelted gold, the result of crushing 4,497 tons of ore.

(*l*) Starlight Reef.

The property containing this reef lies wholly within the coarse granite area, near the Hopetoun Mine. The workings on the reef consist of two tunnels driven in on the lode a little above the bed of Baker's Creek. The strike of the Starlight Reef approximates to an east and west direction.

The lower tunnel has been driven 230 feet into the hill, while the second and higher level has had a winze sunk on it for 60 feet. The ore body fluctuates in size, varying from a mere line to 15 inches in width.

In 1889,	7	tons	10	cwt.	of stone were crushed for a yield of				32	oz.	11	dwt.	0	gr.
„ 1890,	47	„	16	„	yielded ...	...	...	...	83	„	14	„	0	„
„ 1894,	9	„	15	„	„	...	...	...	25	„	16	„	0	„
„ 1895,	65	„	15	„	„	...	...	...	140	„	1	„	12	„
„ 1896,	4	„	2	„	„	...	...	...	11	„	15	„	0	„
Total...	134	tons	18	cwt	for	...	...	...	293	oz.	17	dwt.	12	gr.

Giving an average of over 2 oz of gold per ton of ore crushed.

(*m*) The Sandon Electric Light and Power Company.

This company has almost completed a large dam, on the "anchor crib" weir systen, near the Gara River Falls, 5 or 6 miles distant from Hillgrove. Mr. F. Cotton, M.P., is constructing this dam for the conservation of water, wherewith to drive the mine batteries, and serve the township with the electric light. The dam has an extreme length of 575 feet, a width at the base of 90 feet, tapering to 20 feet wide on top. The construction is of log-cribbing, resting on a granite foundation ; the interstices in the cribbing being packed with gravel and clay. A sheet of water several miles long has been conserved. The minimum supply of water in the dam is said to be 350,000,000 gallons. One and a quarter mile of Oregon pine fluming, 2 feet deep, will conduct the water to an iron pipe 900 feet long, set at an angle of 45 degrees, thereby giving a head of 450 feet. The nozzles coming from the pipe are arranged so as to pour the water on to Pelton wheels, each the equivalent of 300 horse-power. With a loss of 20 per cent. the company expects to deliver 1,000 h.-p. to the batteries through 5 miles of wire.

This company has already lighted up the town by electricity, borrowing the Garibaldi steam-engine until such time as the dam shall be completed.

(*n*) Paradise and No. 9 Antimony Lodes.

At the head of Swamp Creek, two large antimony reefs occur, about 60 feet apart, and underlaying slightly toward each other. Traced down the bluffs of the creek head (Plate III), the Paradise lode is seen to turn off at right-angles and cross the bed of the creek. Close on 2,000 tons of antimony have been extracted from these lines of reef.

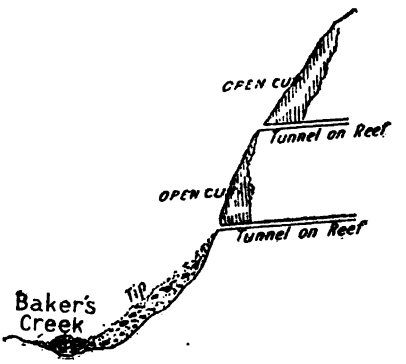
(*o*) Murgatroyd's Tunnel.

This tunnel has been driven 552 feet into the hill just below the Cooney tunnel, and on the Metz side of the gorge, at a cost of about £3,000. This includes also a cross-cut east and west from the tunnel. 188 feet from the entrance of the tunnel a tongue of crushed granite 28 feet wide was cut through, while the end of the tunnel is carried through another granite apophysis. 270 feet from the entrance a formation of yellow crushed slate occurs having a strike of south 27° east, and a dip of 80° to the north-east. It is claimed that this formation is the south-east extension of the Sunlight Reef. A winze has been sunk 30 feet in the cross-cut, and Mr. Murgatroyd intends carrying this down 200 feet. The country is much crushed and faulted.

(*p*) Minor Properties.

The Baalgammon Reef.—The general trend of this vein is north 55° west, with a high general angle of dip in a north-east direction. It thus corresponds closely in strike and dip with its neighbour—the Little Reef.

Sketch illustrating method of working the Baalgammon Reef.



Above the Consols property, the Baalgammon stone has been won by a set of three tunnels driven in on the outcrop of the lode. It was pegged in by Jensen, Maddricks, and Party in 1891. Among various parcels of stone crushed were :—

18	tons	of	ore	for a yield of	35	oz. 11	dwt. of gold.
2	,,		,,		7	,, 14	,, ,,
3	,,		,,		3	,, 6	,, ,,

the latter quantity being raised by tributors. This was in the upper levels. Prospectors working on a supposed lower level on the reef never met with

any payable stone. Aid was procured to cross-cut for a distance of 200 feet from the lowest tunnel; but the applicants availed themselves of the aid for 60 feet only.

Trimm's Tunnel, Mount Carrington Gold-mining Company's Tunnel, and Beiber's Tunnel have been driven into the hill to prove the continuation of certain well-known reefs. Of these, Trimm's Tunnel lies between Murgatroyd's Tunnel and the Sunlight Lode. It has been driven through the formation that crosses Murgatroyd's Tunnel, but there is nothing definite to be seen owing to intense crushing of the country. The other two tunnels were driven to pick up the southern extension of the Little Reef.

Keyes' Scheelite lies completely in the coarser granitite area. It has been proved for a distance of 320 feet along the lip of the Baker's Creek Falls. It varies from 1 inch to 4 inches in width, and occurs in lenticular patches. Much of the ore won is found to contain over 60 per cent. of tungstic acid. From this lode and another but smaller one lower down the hill, 20 tons were raised during the last year.

Maddrick's Scheelite.—This property lies on the west side, and about halfway up the Baker's Creek gully. It contains some pure scheelite. Seventeen tons were raised during the last half year.

Brackin's Spur and Beck's Antimony Lode are two other localities from which considerable quantities of antimony have been raised from time to time.

Sydney: William Applegate Gullick, Government Printer.—1900.

DESCRIPTION OF PLATES.

Frontispiece. Panoramic view of Baker's Creek plant.

II. Whittaker's Spur, seen from the south.

III. Slate and Granite Bluff—Head of Swamp Creek.

IV. View of Baker's Creek Gorge from Campbell's Spur.

V. Eleanora plant, from the east.

VI. Sunlight Tramway. The Tramway crosses the reef.

VII. View of Sunlight Battery, with Baker's Creek Battery in middle ground, and Cosmopolitan in distance.

VIII. Baker's Creek tramway.

IX. Consol's Battery and poppetheads.

X. Micro-photograph, taken under crossed Nicols, illustrating the faulting of felspars in the green basic variety of granite.

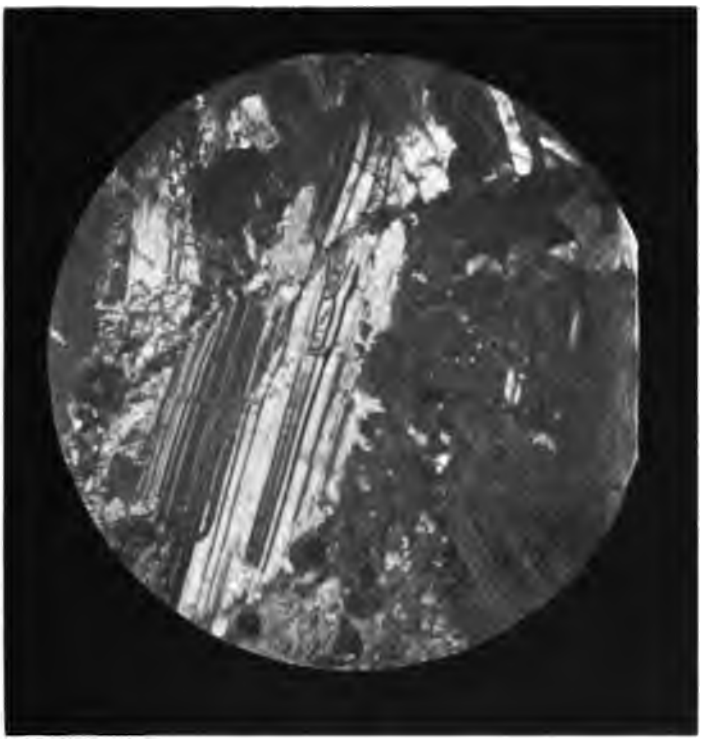
XI. Section of Eleanora workings.

XII. Section of Little Reef, showing amount of stoping.

XIII. Section of Big Reef, showing amount of stoping.

XIV. Section across Big and Little Reefs.

Plate X.



To face page 44.

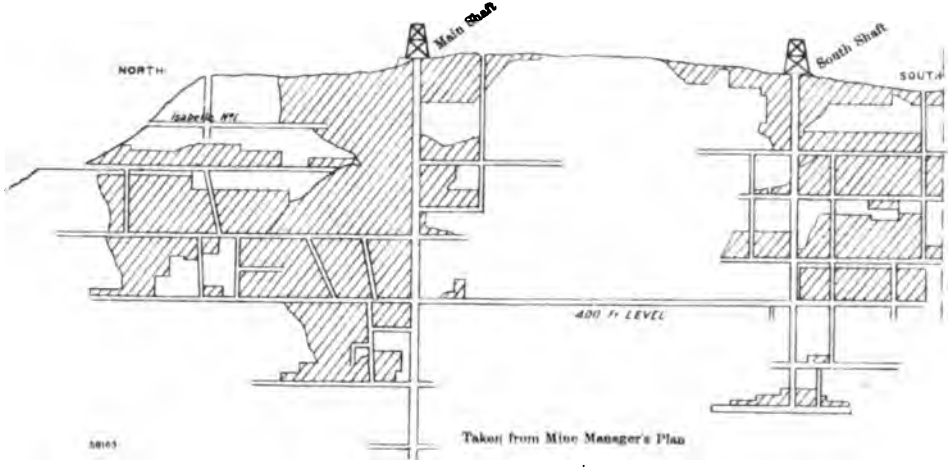
MICROPHOTOGRAPH, ILLUSTRATING FAULTING OF FELSPARS.

SECTION

ELEANORA GOLD AND ANTIMONY MINE

Horizontal and Vertical Scale 0 100 200 Feet

Stopes



Taken from Mine Manager's Plan

Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

Plate XI.

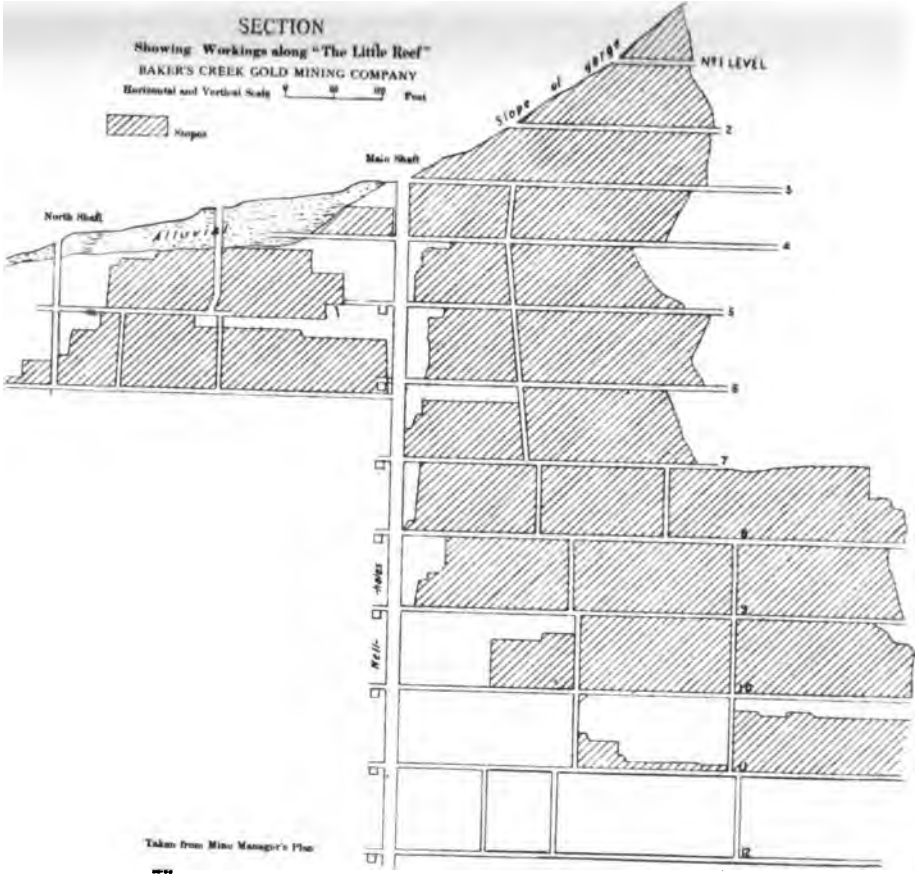


Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

Plate XII.

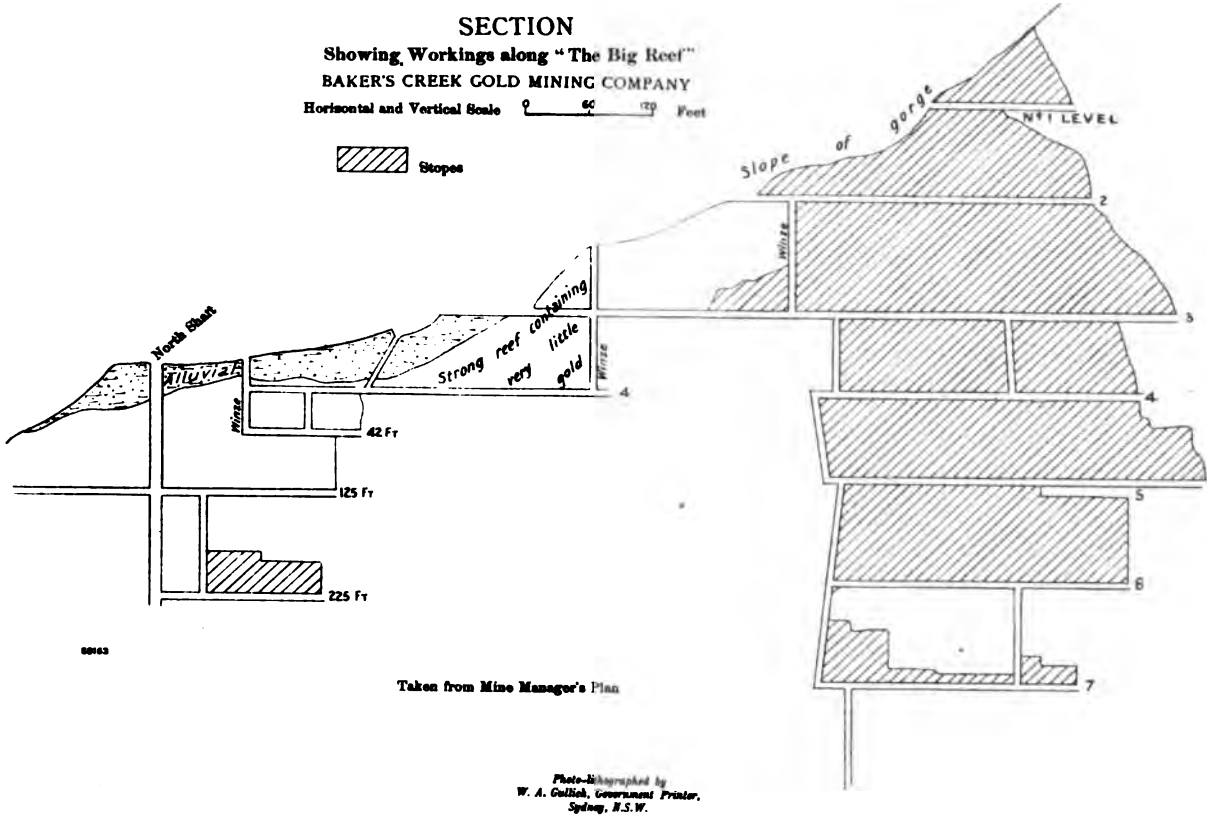
SECTION

Showing Workings along "The Big Reef"

BAKER'S CREEK GOLD MINING COMPANY

Horizontal and Vertical Scale 0 60 120 Feet

Stopes

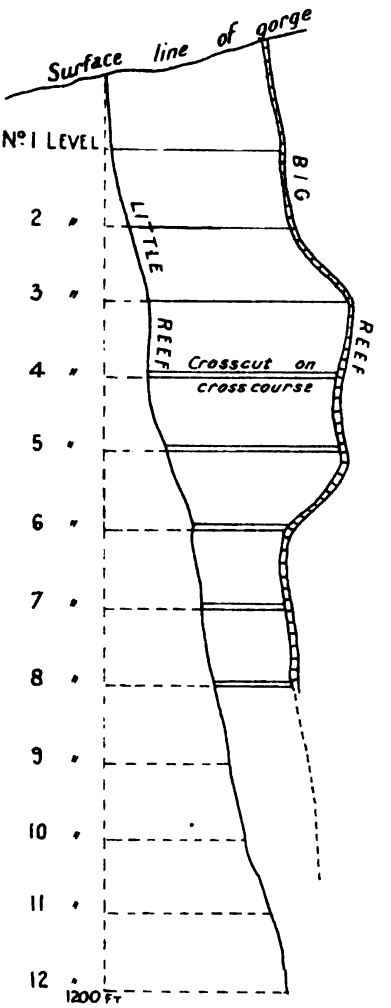


Taken from Mine Manager's Plan

Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

Plate XIII.

SECTION
OF THE
Big and Little Reefs
Scale 0 100 200 Feet

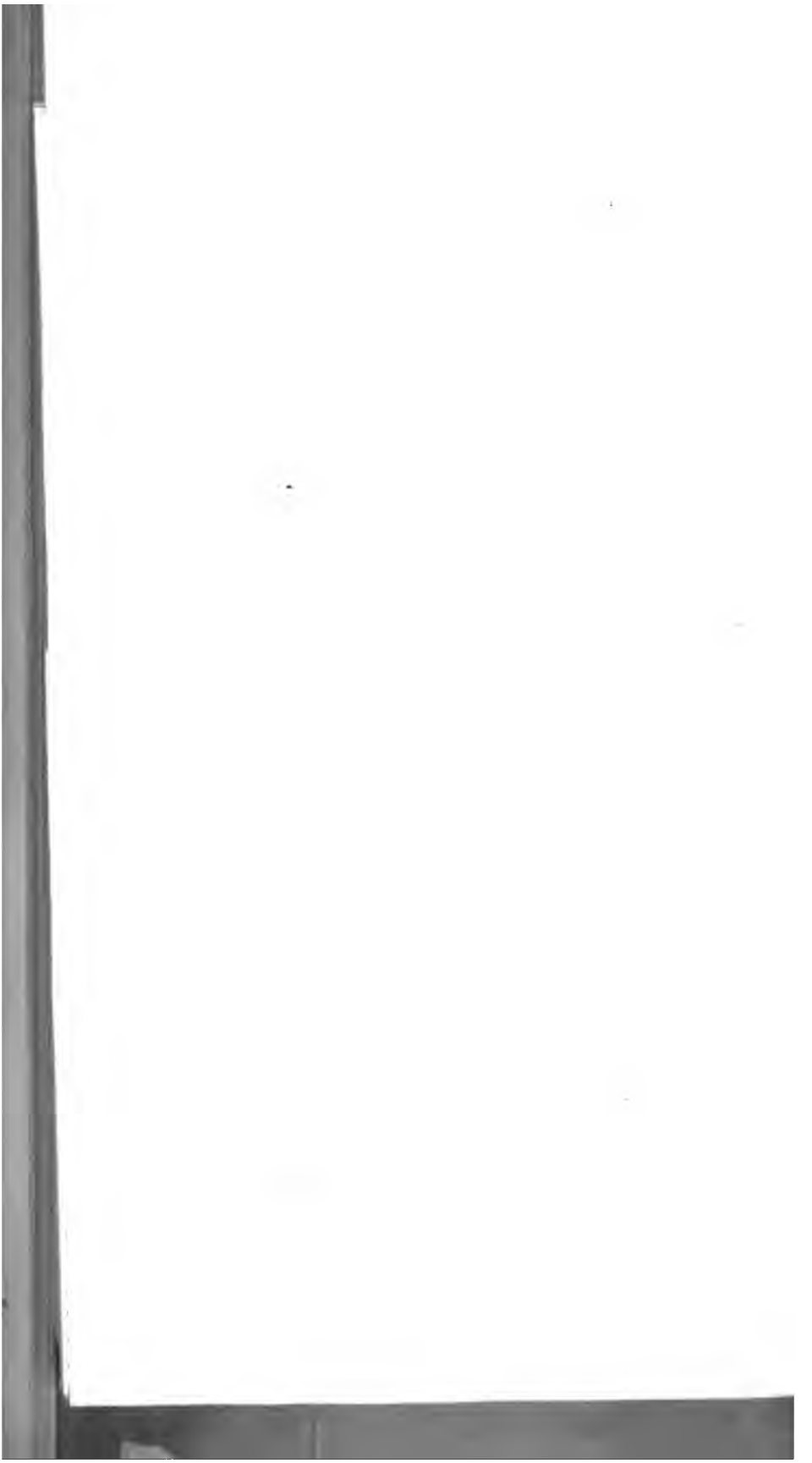


The main shaft is sunk on the "Little Reef" and the ore from the "Big Reef" is won by means of crosscuts driven on a crosscourse from the "Little" to the "Big Reef."

The crosscuts are projected into one vertical plane.

58163

Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.



NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

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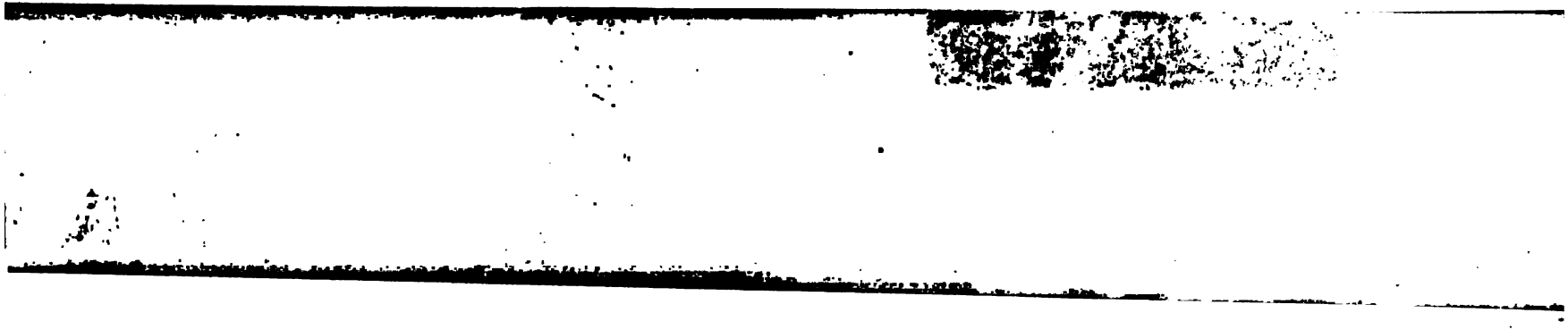

VIEW OF YALWAL FROM THE SOUTH.

NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

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Geological Survey Office,
Department of Mines and Agriculture,
Sydney, 17 October, 1901.

Sir,

I have the honor to submit for publication Report No. 9 of the Mineral Resources Series, being a description of the geology of the Yalwal Gold-field, by Mr. E. C. Andrews, B.A., Geological Surveyor.

Gold-mining operations have been carried on at Yalwal for about thirty years, and although some extremely rich patches of stone have been extracted from such mines as The Pinnacle, The Caledonia, The Pioneer, and The Homeward Bound, it is chiefly upon the low grade ores of the field that the gold-mining industry has had to depend.

The Yalwal field is of interest, owing to the fact that the mining and treatment of auriferous ores has been effected here at a lower cost than in any other part of the State; one of the principal reasons for this is that the ore can be extracted in open cuts or quarries at a very low rate. The gold occurs chiefly as impregnations in indurated slates, quartzites, and conglomerates of Devonian age, and although minute quartz veins are occasionally visible in these, it is found to be more economical to extract and treat the whole of the material rather than to attempt to pick out the richer portions.

The Homeward Bound and Pioneer Mines have been able to pay their way for some years by treating ore of exceptionally low value; and in view of this fact it seems probable that good profits could be obtained if these mines were worked on a much larger scale, as is done, for instance, with analogous ores at the Treadwell mine, Alaska, U.S.A.

EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines and Agriculture.

SYNOPSIS OF CONTENTS.

PREVIOUS REFERENCES TO THE YALWAL AND GRASSY GULLY GOLD-FIELDS.

(1.) In 1852, Mr. A. Mackay, Commissioner of Crown Lands, reported on the geology of Yalwal.*

(2.) The Rev. W. B. Clarke, F.R.S., also reported on the Yalwal Gold-field at various times between 1860 and 1872.†

(3.) Mr. E. F. Pittman, Government, Government Geologist in 1883, made a report also on the Yalwal field ‡

(4.) Mr. J. B. Jaquet, Geological Surveyor, reported on a gold-bearing rhyolite at Grassy Gully.§

(5.) Mr. W. H. J. Slee, Chief Mining Inspector, reported on the Bundundah reefs.‖

(6.) Various Wardens' reports are to be found in the Annual Reports of the Depart, ment of Mines for the years 1878–79, 1880–81, 1887–88, 1888–89, 1889–90-1890–91, 1891–92.

---

* Southern Gold-fields, pp. 39 and 40. † *Ibid.*, pp. 40–45. ‡ Ann. Rept., Dept. Mines for 1883-84 pp. 159 and 160. § Records Geol. Survey N. S. Wales, 1900, vii. p. 17. ‖ Ann. Rept., Dept. Mines, N. S. Wales, for 1889, p. 134.

INTRODUCTION.

MANY of the gold bearing areas in New South Wales are closely connected with granite masses of Carboniferous age.

The main mountain makers of the Cordillera of New South Wales (as also of Queensland) are Carboniferous rocks of basic granite types, and the auriferous areas skirting these masses are more or less dependent on them for their gold supply.*

The gold may be contained in the granite or felsite itself; it may exist throughout the contiguous strata in veins caused by intrusion of the igneous masses, and subsequently filled by circulating mineralised waters; or the gold, under the influence of the igneous masses, may be segregated from the strata themselves into veins or pockets.

Yalwal and Grassy Gully appear to be additional examples of this influence of Carboniferous (?) granitic masses.

In Yalwal itself, the gold, though not mined for in the granite, is yet in such association with it as to suggest its influence.

At Grassy Gully, five miles north of Yalwal, the gold-bearing reefs are contained in an old rhyolite, which exhibits traces of flow structure.†

The rough and mountainous character of the country made Yalwal difficult of access in former times. Even at present the road down the mountain leading to the township contains a grade of 1 in 4½ near the summit. A new road, with a grade of 1 in 12, is almost completed, and this will benefit the Nowra-Yalwal traffic considerably.

Hitherto Grassy Gully has been heavily handicapped for the same reason, although a new road, almost completed to Burrier, will give the residents access to the outer world. All these means of communication with Nowra will make for progress in this district.

---

* Address delivered to Royal Society of N. S. Wales, September, 1900, by Prof. T. W. E. David, F.R.S.
† J. B. Jaquet, Records Geol. Survey, N. S. Wales, 1900, vii p. 17.

The map of Yalwal Gold-field accompanying this Report is fairly accurate with respect to the central portion. The junctions of the sandstone with the granitic rocks to the north-west and south-west of the map are, however, approximately correct only. This is due to the broken nature of the country, and the scrubby character of the vegetation.

I desire here to cordially thank Mr. A. F. Mixner, manager of the Homeward Bound Mine; Mr. V. Petherick, the former manager of this property; Mr. I. I. Chapple, manager of Mr. A. Hay's properties; Mr. C. Potts, B.A.; Mr. John Maclean, of Nowra; Mr. Durkin, manager of Grassy Gully Mine; Mr. A. Hielman; Mr. H. Martin; Mr. J. Sivewright; Mr. G. Davidson; and many others, who have most courteously volunteered both help and information.

The maps and sections, were prepared by Mr. O. Trickett, L.S., of the Geological Branch.

History of the Development of Mining at Yalwal.

In 1852, Mr. A. Mackay, Commissioner of Crown Lands for the County of St. Vincent, communicated with Mr. J. R. Hardy, Commissioner of Crown Lands, concerning the geological and auriferous character of the Yalwal District.*

During various periods between 1860 and 1872, the Rev. W. B. Clarke, examined the district under consideration in some detail.†

In these earlier days the whole country stretching from the mouth of the Yalwal Creek to the head of the Yarramunmun (known as Sassafras), belonged to W. Elyard. Toorooroo, situate at the junction of the Danjera and Yarramunmun Creeks, was the head station; and close to this spot, early in 1870, the first real efforts at prospecting were undertaken.

The original prospectors were Messrs. J. Sivewright, J. Brakewell and S. Donovan. The site chosen for working the alluvial was along the Danjera, immediately above its confluence with the Yarramunmun. Here 350 feet of boxes for sluicing operations were set up. From this alluvial claim, J. Sivewright, with six men on wages, recovered 1½ to 2 ounces of gold per week.

The great flood of 1871 washed away all the sluicing apparatus, and caused suspension of operations for a time.

In the same year, and a little higher up the creek, J. Sivewright and E. Curtis discovered reef gold *in situ*. The spot is now known as "The Pinnacle" or No. 1 Claim. The stone was found on the summit of a bluff rising some 150 feet out of the creek.

Prospects were crushed in a sandstone mortar.

A parcel of 2 cwt. was sent to Mort's, in Pitt-street, with a result of 7 dwt. per ton from surface stone. This dismayed the prospectors for a while, but on Sivewright's return from Queensland in 1873, he essayed a second time the working of the Pinnacle.

From a small parcel of ore 30 oz. of gold were obtained. For four months' work the result was 140 oz. of gold.

The stone was carried down the bluff to the creek, and dollied there by means of crowbars working in nail cans. By preliminary roasting of the ore each man was enabled to crush 56 lb. weight per day. The gold was then amalgamated dry after passing the crushed material through very fine sieves. The prospects being still payable, one of Dr. Beer's one stamper spring machines was procured. This gave a strike equal to 2 cwt. One man with this machine could crush half a ton of stone per week. The returns were from 24 to 30 oz. per ton, extracted from hard clean quartz.

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* W. B. Clarke, Southern Gold-fields, pp. 39-40. Also Appendix I to this report. † *Ibid*, pp. 40-45. Also Appendix II.

Shortly afterwards, a 3-head battery, constructed at Lutton's, supplanted Dr. Beer's machine. With the improved machinery, 3 to 4 tons of stone were crushed every week.

In 1871, alluvial gold was obtained in Sawpit Gully. The metal was coarse in character, but did not appear to occur in payable quantities.

E. Aldis and J. Caddle discovered gold in 1872 from surface prospects on the property now known as the Pioneer. The stone was treated at the creek below, but the gold was of too fine a nature for the crude methods of saving employed, and prospecting was discontinued on this claim for a period.

About the year 1874 Michael Harvey and another found gold on the present Homeward Bound Claim.

About the year 1875 J. MacArthur & Company erected a 5-head battery, driven by an engine of 8-horse power. It was an odd five of an original 30-head battery, procured for the Upper Shoalhaven River.

A 16-ton parcel was made up from the Homeward Bound Claim, and crushed at this battery. The result was 1 oz. 6 dwt. per ton.

J. Sivewright and Party hired this plant for their work, its crushing efficiency being 40–45 tons per week.

Gold in the stone (the Pinnacle) varied from 1–3½ oz. per ton. The Pinnacle owners used this plant for 12 months. The property was then taken up by a company of 24,000 £1 shares, with 12,000 paid up to £1.

The Homeward Bound Claim was then taken up by T. Thorburn and Party. In 1887 they bought a 10-head battery from J. MacArthur & Company, which had been originally used for public crushings, and fixed it on the site of the present cyanide plant. A shaft was sunk for 50 feet on a quartz vein, but later, finding that the gold was scattered in "stringers" throughout the country, the company excavated a large chamber in the vicinity of the quartz vein. More gold was found from surface crushings near the original workings. The surface was then broken through and the open cut system established. The country was worked north and south for gold.

As the success of the Homeward Bound Claim became assured, another trial was made on the adjoining Pioneer property.

A shaft was sunk on a small quartz "leader," and good returns were crushed from the same. Stoping was resorted to, and several crushings taken from both shaft and stope.

Prior to 1885, the original company (consisting of T. Thorburn, J. Maclean, and 30 others) had sunk the shaft 60 feet.

The claim next to the Pinnacle on the north, and known as the Eclipse or No. 2, was taken up by J. Maclean and Party about the year 1874.

A 10-head battery was erected in 1878. This was purchased from Dr. H. J. Tarrant. The second crushing gave a result of 7 oz. gold per ton from 761 tons of ore.

In 1881, £2,795 worth of gold was extracted from this claim.

In 1880, E. Curtis and E. Fletcher discovered gold in a claim north of the Eclipse property, and known as the Poor Man.

In February, 1881, a 15-head battery was procured for the Pinnacle Company from the Atlas Works. This company at the time mentioned was known as the Yalwal Quartz-mining Company.

The "Star" lease was taken up by Kennedy, Maclean and Party in 1883. The shareholders numbered eighteen. £2,000 were spent in driving tunnels without any return.

This property immediately adjoins the Homeward Bound lease to the south, and it was the prosperity of the latter which urged the lessees of the Star to take up and explore the claim.

Accordingly three tunnels were put in as closely as possible to the southern boundary of the neighbouring property. The tunnels were driven vertically above each other in the rough hillside which composes the claim.

The lower tunnel was started in 1883 and completed in 1885. Its length is 450 feet and its direction easterly. This is near the level of the creek.

The upper tunnel was driven by Peter Matson in 1887, under the sandstone capping of the hill, and 350 feet above the level of the creek. The total length driven was 200 feet.

From this part of the claim 10 tons of stone were extracted in 1893, yielding an average of 7 dwts. of gold per ton.

A middle tunnel was also driven about 100 feet below the upper one between the years 1890–92. The total length driven was 350 feet. Prospects amounting to 10 and 12 dwt. per ton were obtained from this working.

Prior to 1885, the work on the Pioneer consisted of a shaft some 50 or 60 feet deep, and a few small surface workings.

Mr. J. Hanson, in 1890, bought the property for £15,000. Stone taken from various spots on the lease gave satisfactory results, individual crushings yielding returns as high as 3 oz. per ton. Three quarries, or open cuts, exist on this property. The two westerly ones represent earlier exploitings for gold. The eastern one, shown on the map as continuous with the Homeward Bound open cut, is of more recent date than the others.

A tunnel was driven nearly 900 feet into the hill in 1891. In 1901 the tunnel was carried a further 100 feet. The idea was to test the hill, and to connect the open cuts with the battery.

Another tunnel at a higher level was driven 400 feet to prove the property, and to connect the workings with the main pass.

A 40-head battery was erected by Mr. Hanson in 1891.

The property was then resold to a Nowra syndicate, having practically the same *personnel* as the original company. This was in 1892.

The approximate cost of erecting the mining plant and in developing the property was £27,000.

The Caledonian Claim was taken up in 1885, and amalgamated with the Star in 1887.

In that year, prospectors found an auriferous vein in the first-named property. A 5-head battery for public use was employed, a road being cut round the hillside to convey the ore to the battery. One hundred tons were crushed from the lease for a return of £500, the maximum yield being 6 oz. per ton.

The road just mentioned passed through what is now known as Underwood's Cut, splendid stone lying unnoticed on the roadside for four or five years.

The mine lay idle until 1892, in which year W. Underwood and R. Johnson took the mine on tribute. Opening up a small quartz vein showing in the roadside at Underwood's Cut, they crushed, at the first trial, stone varying from 23 to 30 oz. of gold per ton. From this vein, varying from 3 to 9 inches in width, they crushed £3,500 worth of gold in three months.

One parcel of 34 cwt. yielded 750 oz. of gold. This rich stone was, from all accounts, very unpromising in appearance; only on being crushed or scratched did it reveal its true nature. The tributers, apparently, then lost the vein against a "floor."

Fletcher Brothers then took the property on lease from the original tributers. Following the "floor" up, they again came on the vein, which proved richer than before.

Fletcher Brothers won £6,500 worth of gold as the result of their tribute.

These latter then closed in with an offer of £950 from the original company, who, in a short space of time, extracted gold to the value of £6,900.

Other veins, running parallel to the direction of Underwood's Cut and known as Ison's and Sandeman's Cuts, were worked also with success, the stone varying from 2 to 6 oz. of gold per ton.

In 1886, the Eclipse Company, having excavated a system of large chambers from an extensive lode formation, connected the same with their battery by means of a long and sinuous tunnel.

From 1882 to 1889 the Homeward Bound Company crushed with a 10-head battery.

In 1885, £5,132, and in 1887, £6,105 worth of gold was won by the company.

After 1889, the property was sold to the Homeward Bound Gold-mining Company, who erected twenty head of stampers (exclusive of the original 10-head battery).

In 1891, another twenty head of stampers was added, and two years after the original 10-head battery was incorporated with the 40-head, to form a 50-head battery.

From June, 1893, to December, 1896, the mine was hampered considerably, sometimes closed altogether, owing to litigation.

This threw the miners out of employment, and an alluvial prospect being found by Middleton and Prince, in a shaft 15 feet deep, in Sawpit Gully, a small rush took place in 1893.

Thirty men were soon at work, the gully being rushed, although the ground was leased. £2,500 worth of gold was extracted in eight months. Nuggets varying in weight from 15 dwts. to 2 ozs. were found.

In 1894, J. Sivewright and T. Mason attempted to sink through a vesicular dolerite at Grassy Gully (five miles north of Yalwal) for alluvial gold.

The following year, R. Ison and Charles Moffatt discovered payable gold at the same locality (Grassy Gully).

This was in close proximity to the sandstone cap which forms the ridge between the Shoalhaven River and Yalwal Creek. The auriferous belt was found to extend in a north and south direction through a rhyolite flow, and the country was rapidly taken up over a narrow area exceeding a mile in length.

In 1896, a great number of the minor properties belonging to the Yalwal area were worked with varying success.

In this year 113 tons of stone were crushed, for a return of 188½ ozs. of gold, from "The Golden Quarry" (G.L. 27.28).

In the early part of February, 1898, a cyanide plant was erected by the Pioneer Company.

During the same month, the Homeward Bound Claim was placed under new management. Mr. Petherick came into charge, and, in view of the low class of the ore, he decided to erect an experimental cyanide plant.

Mr. A. F. Mixner had charge of the cyanide plant. It worked so well that a much larger plant was erected, which ultimately became the mainstay of the mine.

In November, 1900, Mr. Mixner was appointed general manager.

Moffatt, one of the discoverers of Grassy Gully gold, took up a lease in this locality in 1895, and sold, shortly afterwards, to the Anglo-Australian Company. The lease was forfeited in June, 1898, and taken up by Messrs. Hanson and Barron, by whom it was worked for nine months.

It was then sold to Mr. W. H. E. Lovely and Party, and worked for six months.

In January, 1900, it was formed into the Grassy Gully Gold-mining Company, with P. Durkin as manager.

The mine had been sunk to 185 feet in June, 1900.

A 10-head battery and a Wilfley vanner were erected in September, 1900.

Summary.

1852. Report on Yalwal, by Mr. A. Mackay. Reports by Rev. W. B. Clarke, F.R.S.
1870. Prospecting for alluvial by J. Sivewright and Party.
1871. Abandonment of sluicing operations. Alluvial found in Sawpit Gully. Discovery of gold *in situ* (Pinnacle).
1872. Gold discovery in Pioneer Claim.
1873. Pinnacle worked a second time.
1874. Gold discovered in Homeward Bound Claim. Eclipse Claim taken up (?).
1875. Erection of 5-head battery for public crushing purposes.
1878. Ten-head battery erected for Eclipse Claim.
1880. "Poor Man" discovered.
1881. Fifteen-head battery procured for Pinnacle.
1883. "Star" lease taken up.
1885. "Caledonian" lease pegged out.
1887. Homeward Bound Company purchased 10-head battery.
1889. Additional 20-head of stampers erected for Homeward Bound Company.
1890. Mr. J. Hanson purchased Pioneer property for £15,000. Forty-head battery erected for Pioneer property.
1891. Pioneer Lower Tunnel driven 850 feet.
1892. Additional 20-head battery erected for Homeward Bound Company. The old 10-head included, bringing total up to 50-head. W. Underwood and R. Johnson crushed £3,000 worth of gold in three months from Caledonian Claim. Pioneer property rebought by original shareholders.
1893. £2,500 worth of alluvial gold won from Sawpit Gully.
1894. T. Mason and J. Sivewright attempted to sink through dolerite for alluvial in Grassy Gully.
1895. C. Moffatt and R. Ison discovered gold at Grassy Gully. "Grassy Gully Mine" started. Pioneer and Caledonian properties yielded £18,565 worth of gold. 4 tons crushed from Caledonian for 1,664 oz. of gold.
1896. Numerous minor properties worked.
1898. Cyanide plant erected for Pioneer Claim. Experimental cyanide plant erected for Homeward Bound Claim.
1900. Present Homeward Bound cyanide plant erected (March). Ten-head battery and Wilfley vanner erected at Grassy Gully.

Physical Geography.

Yalwal, by road, is about eighteen miles west of Nowra. It is approached from the latter by crossing a couple of ridges, and is situate at the base of a gorge, through which the Danjera Creek flows in its passage to the Shoalhaven River.

For a distance of seven miles out of Nowra, the road makes a gradual ascent for about 600 feet. Saltwater Creek is then crossed. Thence to the 16-mile peg, the road follows a narrow ridge, at which point a descent is made of 900 feet to the junction of the Danjera and Yarramunmun Creeks.

Drainage System.—The Shoalhaven River has a northerly course from Braidwood to Bungonia. A little below the latter place, however, it alters its direction sharply to the east. Sweeping clean through the mountainous belt between Bungonia and the coast, it persists in its new course until it reaches the sea, eighty miles distant. In this easterly direction it drains the whole of the Yalwal District, and takes in also the waters of the Kangaroo River.

The country is very rugged and broken, especially to the west of Yalwal. The district represents a thoroughly dissected plateau with ridges or "razorbacks" marking the extensive denudation to which the old upland has been subjected, and, at the same time, separating the various creeks, which feed the Shoalhaven, from each other.

From an eminence immediately behind the village of Yalwal, and 1,250 feet above the Danjera Creek, the leading features in the topography can easily be made out.

To the north and west the Shoalhaven River has eroded an old sandstone plateau to a marvellous extent. From the spot where it gathers in the waters of the Kangaroo River (and also far above this point) to its junction with the Yalwal Creek, bold escarpments, 2,000 feet and more in height, with cliffs 1,000 feet high in places, mark the course of the cañon-like valley of the main stream.

A little below its junction with the Yalwal Creek, the river spreads itself over the flatter country caused by the retreat of the hills from the stream. On the east bank, the huge pile known as the Cambewarra Mountain (a portion of the coast range), 2,000 feet in height, divides the waters of the main stream from its large tributary, the Kangaroo River. This highland supports luxuriant growths of grass, which constitute one of the sources of wealth of the district. Thence towards the sea the mountains dwindle in height, and with the exception of Coolongatta, a rounded eminence, 1,000 feet high, they become less and less separable from the gentle undulations of the surrounding country.

The creeks in the immediate neighbourhood of Yalwal are the Danjera (Plate II), the Right Arm or Bundundah, the Ettrema, and the Yarramunmun. These have approximately parallel courses for considerable distances, finally joining the Yalwal near its confluence with the main stream.

The sandstone cap constituting the former plateau at one time extended in unbroken continuity from the present coast line through Yalwal and across the Shoalhaven River. This has since been trenched or dissected so thoroughly in the vicinity of Yalwal by the creeks just enumerated that their courses are marked by gorges varying from 1,000 to 1,500 feet in depth, the summits of their various watersheds being represented merely by lines of cliffs in many places not more than a chain in width.

The cap comprises two series of hard sandstones, with soft intercalated shales. These harder beds divide the district into two "platforms" or "terraces." The upper some 200 feet thick and from 1,200 to 1,400 feet above the creeks, forms precipices over which the pioneers of the district found it difficult to force a way. Also a lower platform 500 feet below the upper one, and some 150 feet in thickness. This also faces the valleys in precipitous manner.

The upper series is broken here and there by lower gaps or passes allowing ingress and egress to and from the valleys.

The hard strata underlying the sandstone cap are exposed at a general height of 500 feet above the creeks. These, unlike the sandstone (which forms "terraces"), weather out into long hard spurs, which advance to the creeks from the cliffs above, after the manner of great buttresses.

These platforms or "terraces" are to be expected in greatly denuded horizontal strata, where the beds are of varying hardness. A still later phase of denudation is the "mesa" stage, when creeks have so intersected a plateau as to leave isolated flat-topped hills with precipitous sides. Several examples of these occur in the vicinity of Yalwal. They are about 1,000 feet in height, have high cliffs surmounting very steep slopes, and possess quite flat tops, a few acres only in extent.

GENERAL VIEW OF DANJERA CREEK FROM THE PINNACLE CLAIM. PIONEER AND HOMEWARD BOUND BATTERIES IN THE MIDDLE GROUND.

The appearance of the Devonian rocks conforms also to the generally observed order of phenomena in the weathering of strata nearly vertical, containing beds of varying hardness, *i.e.*, rough spurs with dyke-like formations (representing the harder layers), running parallel to the strike.

The valleys widen in and out most capriciously. The trend, however, of the minor streams is nearly north and south.

Five miles above Yalwal, along the Danjera Creek, bluffs occur nearly 1,000 feet in height, composed of red granite and rhyolites.

Meteorology.—Yalwal, although eighteen miles only from Nowra, experiences intense heat in summer. This is due to its being cut off from sea influences by a mountain ridge, 1,100 feet high, rising immediately to the east of the village and trending so as to intercept any sea breeze; to the narrowness of the gorge itself in which the village is situated; and to the fact of its being less than 200 feet above sea level. On exceptional days the shade temperature reaches 115° Fahrenheit.

The rainfall varies from 40 to 50 inches per annum.

Vegetation.—The granite areas contain great escarpments supporting a very meagre and stunted vegetation.

The sandstone below the upper line of cliffs supports dense growths from six to ten feet high, through which it is difficult to force one's way. The lower gullies, enclosed by the spurs of Devonian strata, are full of myrtle and allied growths, while the basic igneous rocks may at times be traced by the luxuriant crops of grass they support when cleared of timber.

General Geology.

The surface of the Yalwal District being much broken, very little difficulty is experienced in ascertaining the various sedimentary and igneous rock junctions. They are, however, obscured in many places owing to the great amount of talus derived from the Permo-Carboniferous sandstone, and the thick scrub-growths that fill the gullies.

The geological formations of this locality are as follows:—

1. Recent and Pleistocene—Alluvium and river terraces.
2. Permo-Carboniferous—Lavas and tuffs, upper marine sandstones.
3. Carboniferous—Granites and quartz-felspar porphyries.
4. Devonian—Dolerite sills, rhyolite lavas, dolerite lavas, slates, quartzites, conglomerates, schists, and shales.

1. *Recent and Pleistocene.*—To this date belongs the period of deposition of alluvium in the various creeks about Yalwal. The Shoalhaven is said to possess river "terraces" or marks of former river levels. These may be referred to this period also.

2. *Permo-Carboniferous.*—The formations of this period consist of a huge covering of sandstones, grits, and mudstones, which formerly extended across the whole of the district. The older underlying formations have been exposed by the erosion of this Permo-Carboniferous crust.

To understand the geological position of this sandstone cap, a brief *resumé* of conditions obtaining in New South Wales during Permo-Carboniferous times is inserted here:—

The Permo-Carboniferous period was the great coal making epoch of the southern hemisphere, and is further remarkable by reason of great alternating periods of heat and cold (glacial periods) which occurred shortly after the Carboniferous period.

In New South Wales, the period is divided into several great divisions.

The oldest beds comprise *The Lower Marine Series*, consisting of various sedimentary rocks containing marine fossils. This series is 4,770 feet in total thickness, and contains abundant evidence of glacial action in its lower beds.

The *Greta Coal Measures* were then laid down. The equivalent of these in the South Coast District is the *Clyde Seam.*

To this succeeded the *Upper Marine Beds*, a mass of sedimentary rocks 5,000 feet in maximum thickness. Especially well are these beds developed in the Maitland District. Great periods of cold occurred also during the deposition of these beds.

It is to this latter series that the Yalwal sandstones belong. They lie directly on the older Carboniferous granite and Devonian inliers with no intervening coal seam (Clyde); since the granite hills represented high land during the deposition of the Greta or Clyde coal.

Subsequently the great *Maitland* and *Newcastle Coal Measures*, with a total thickness of 3,900 feet, were deposited. Both of these are supposed to have coalesced to the south to form the *Bulli Seam.* This also is absent from Yalwal. If present it would form a cap to the sandstone above the Yalwal Trig. Station.

After the deposition of the coal measures a great period of volcanicity supervened. The lavas and tuffs of Cambewarra and Kiama are expressions of this volcanic activity.

3. *Carboniferous.*—To this period the granites and quartz-felspar porphyries of the district may be assigned.

4. *The Devonian.*—The formations belonging to this period consist of rhyolite and basic lavas, basic sills, and various metamorphosed and folded strata.

The Permo-Carboniferous sandstone, although subjected to extensive denudation, still occupies by far a greater extent of the surface rocks than those of Carboniferous and Devonian age. Only at the bases of the ravines can the latter be examined, with the exception of a few granite and rhyolite hills lying some six miles to the south and south-west of Yalwal. These were the more prominent features of the landscape in early Permo-Carboniferous times, just prior to their sinking below the sea in the Upper Marine period. Even these higher points are, however, but partially exposed.

It will thus be seen that our knowledge of the formations older than the Upper Marine are confined to exposures found in the lower parts of the various gorges of the district.

Yarramunmun Creek.—In following this watercourse above its junction with the Danjera, a narrow belt of contorted strata is found underlying the sandstone as far as Dean's Flat. A valley existed here in the Pre-Upper Marine times, and sandstone alone is found filling the basin.

The Danjera Creek at Yalwal exposes numerous belts of basic igneous rocks, whose strike conforms to that of the contorted strata they are associated with. Two miles above the village these open out into steep grassy hills abutting on to the creek, while immediately alongside of these rise rough, broken hills of quartz-felspar, porphyry, and granite.

Four miles above the village the granite advances across the creek, and occupies most of the valley slopes.

A couple of miles higher up still, great precipitous faces of rhyolite succeed to the rounded masses of the coarser granite. In places these rhyolite masses rise nearly 1,000 feet above the creek, and present the appearance of the rougher granite gullies of New England.

The formations exposed by the Right Arm or Bundundah Creek are repetitions, mainly, of those found in the Danjera Creek. Amygdaloidal lavas are very plentiful. Quartz-felspar porphyries are in evidence toward the head of the creek. The lower five miles of the creek sides consist of a fine grained and very siliceous granitic type of rock.

The Yalwal Creek slopes from their start as far down as Mackenzie's Station, consist almost solely of granite and porphyries. The land at the station itself is a series of steep, well-grassed downs, consisting of vesicular basic rocks, with long lines of acid rocks either alternating with or intrusive into the basic rocks.

Thence to the Shoalhaven the underlying rocks occur as bold escarpments of contorted strata and felsite lavas. Especially well are these seen near the junction of the Ettrema and Yalwal Creeks. Cliffs several hundreds of feet in height expose sections of strata bent into almost perfect folds, standing out in sharp contrast with the overlying horizontally bedded sandstone.

Near the Shoalhaven the sandstone encroaches on the Yalwal Creek, and occupies even the lowest part of the gorge.

The older formations between Yalwal Creek and Grassy Gully are almost entirely hidden beneath the sandstone cap.

At Grassy Gully itself, the older rocks are exposed in part and rhyolite flows associated with basic amygdaloidal rocks occupy the gold mining area.

It will thus be seen that (*vide* map) a very large area of the underlying rocks consist of rhyolites, quartz-felspar porphyries and granites. They may be considered as extending from the village west and south-west right under the sandstone across the Right Arm Creek, and northwards for miles along the Yalwal Creek.

A considerable area is occupied also by basic igneous rocks.

These basic rocks, intrusive or as contemporaneous flows, consist of amygdaloidal and compact ophitic dolerites and basalts in an advanced stage of decomposition.

The order of succession appears to be as follows:—First, a series of Devonian mudstones, sandstones, and allied rocks were laid down.

Intermittent periods of intense volcanicity occurred at this period, during which immense rhyolite and basic flows were poured forth from various local centres.

The higher members of the Devonian series consist of soft shales, grits, and soft and hard brown tuffaceous material containing numerous *Lepidodendron* remains. With these are associated several sheets of very vesicular dolerite, numerous dolerite sills, and smaller rhyolite flows.

The dolerite sills may be contemporaneous with some of the interbedded sheets, or they may be of later origin.

At a much later date, probably in Carboniferous times, quartz-felspar porphyries (typically as vertical bosses or tongues) and red granites of most pronounced acid affinities made their appearance.

To this date, also, probably belongs the age of the auriferous deposits.

The whole surface then suffered long-continued denudation, causing the aforetime fairly deeply-seated granite masses to stand out boldly above the general surface.

The sinking of the district was accompanied by a deposit of Upper Marine sandstone.

Subsequently the slumbering volcanic forces again came into play, and the basic lavas and tuffs of Sassafras, Cambewarra, and Kiama resulted.

The reasons for assuming these ages and the order of succession is as follows:—

The Age of the oldest Strata.—These are assigned to the Devonian, both on account of their lithological characters and their mode of occurrence.

The Rev. W. B. Clarke* placed these sediments in two divisions—

(1) An upper series containing *Lepidodendron* and *Sigillaria*. These he included as Carboniferous.

(2) A lower series composed of quartzites, slates, &c., and comprising the gold-bearing rocks. These he placed in the Silurian.

Lepidodendra obtained from Mr. Clarke's upper series have been described as follows by Mr. W. S. Dun, Palæontologist to the Survey:—"A most interesting, small-patterned *Lepidodendron*. The leaf bases vary in size from 3mm. x 2·25mm. to 4mm. x 3mm. Several specimens, however, show a more elongated form—7mm. x 4mm. The leaf cushion is well raised, about one-third along axis from the apex of the leaf-base. The print of the vascular bundle is well marked. No traces of parichnos or ligule are preserved. There appears to be no doubt that this species is new. The smaller leaf bases have much the appearance of some forms described as *Ulodendron* (without the large rounded scars). There is an apparent resemblance to forms of *L. Sternbergi* and *L. Heeri*, Nathorst from Spitzbergen. A description and figures will be published in the forthcoming "Records of the Geological Survey."

The *Sigillaria* mentioned by the Rev. W. B. Clarke has not been discovered since.

In the Eclipse and Pinnacle workings well-preserved *Lepidodendra* occur, and identical with those found in the upper beds.

The broad belts of conglomerate traversing the Pinnacle, Eclipse, Golden Crown, Usher, and Caledonian Claims are also probably closely related with the less altered conglomerates of the Jinkbilly Creek.

The evidence points, therefore, to one formation rather than to two distinct periods of deposition. The apparent break in the geological continuity is caused by altered topographical conditions occasioned by the sudden disappearance of the amygdaloids, whose presence causes steep grassy downs, and whose absence allows of rugged gullies in the slates and quartzites, and a fold in the country which has given the idea of a basin (containing *Lepidodendron* remains) in the midst of older formations.

The old rhyolites and dolerites around Grassy Gully appear to be contemporaneous with the associated Devonian strata.

Two great sheets of rhyolite lava are separated by a 2-chain wide band of very vesicular dolerite.

Between the dolerite and the upper sheet a thin selvage of tuffaceous mudstone and slate occurs.

The rhyolites to the south of Yalwal represent yet other enormous acid flows, or the continuation of those occurring at Grassy Gully and cut off by the granites.

Here, also, two rhyolite sheets are separated by a large dolerite sheet. Between the two a belt of basic tuffs occurs.

The banded nature and characteristic contortion flow-structure of the rhyolites, the presence of acid tuffs, the very marked vesicular character of the dolerites, the presence of basic tuffs, the intercalation of mudstones, shales, and allied rocks with the igneous rocks, and the coincidence of strike as regards both igneous and sedimentary rocks, point to great alternating submarine outbursts of acid and basic lavas in Devonian times.

* Southern Gold-fields, pp. 41, 240; also Appendix 2 to this Report.

"THE BUCK REEF." AN ALTERED CONGLOMERATE BELT NEAR THE PINNACLE CLAIM.

THE GAP SHOWING BLUFFS OF UPPER MARINE SANDSTONE.

The sills (?) are placed as younger members of the series, on account of their apparent origin :—

(*a*) They are unaccompanied with tuffs.

(*b*) They transgress planes of bedding in places.

The granites and quartz-felspar porphyries send out long red aplitic dykes into the surrounding strata, the rhyolites, the basic lavas, and sills alike.

Both the granites and porphyries possibly represent different phases of consolidation of a plutonic mass, and thus may be of the same age.

In this limited area we have then :—

(*a*) Alternating basic and acid lavas of Devonian age.

(*b*) Granites and microgranites of Carboniferous age.

(*c*) Basic lavas of the Permo-Carboniferous.

The alternation of acid and basic lavas in Devonian times points, possibly, to a remarkable differentiation of a common magma. What that magma consisted of is not yet evident, as no plutonic "boss" has been discovered in the district which could serve as a feeder to the various lavas of the locality.

B.—Sedimentary Rocks.

(*a*) *Recent or Pleistocene.*—As mentioned before, to this period belong the alluvial of the creeks and the river terraces (?) of the Shoalhaven.

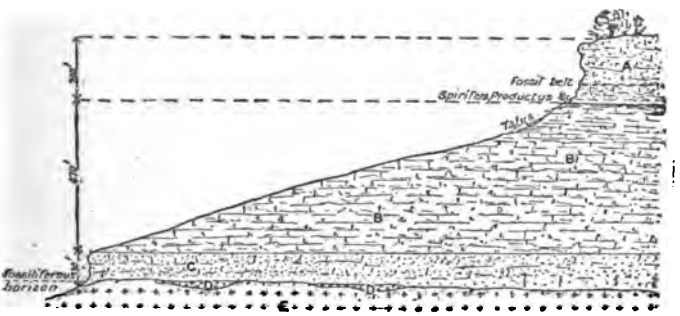
(*b*) *Permo-Carboniferous.*—This is represented by a thick capping of coarse and fine sandstones, mudstones, and shales of Upper Marine age.

The maximum thickness of the beds, occurring some two miles south-east of Yalwal, is 1,000 feet, and the general thickness varies from 600 to 800 feet.

The strata fall naturally into three divisions (see sketch) :—

(1) Lower.
(2) Middle.
(3) Upper.

Section of Sandstone Cap near Yalwal.



A. Upper hard belt of sandstone.
B. Middle belt of soft shales, sandstones, &c. ; almost barren of fossils.
C. Lower hard belt of sandstone.
D. Conglomerate.
E. Granite.

(*a*) *Lower Beds.*—These consist of hard belts of sandstone varying from 25 to 200 feet in thickness.

The basal beds lie upon patches of conglomerate, and consist for the greater part of coarse and hard sandstones, brownish-black, red, yellow, and white in colour. Intercalated with these are soft white sandstones and mudstones containing numerous plant impressions.

The cementing material consists generally of red and yellow oxides of iron, with traces of manganese oxide.

Numerous fossil remains occur in the lowest of the beds.

The conglomerates, which are very patchy, and appear to occupy local hollows once existing in the underlying formations, are composed of granite and quartz pebbles.

(*b*) ***Middle Beds.***—These comprise a mass of soft sandstones, mudstones, and carbonaceous shales, weathering into gentle land slopes.

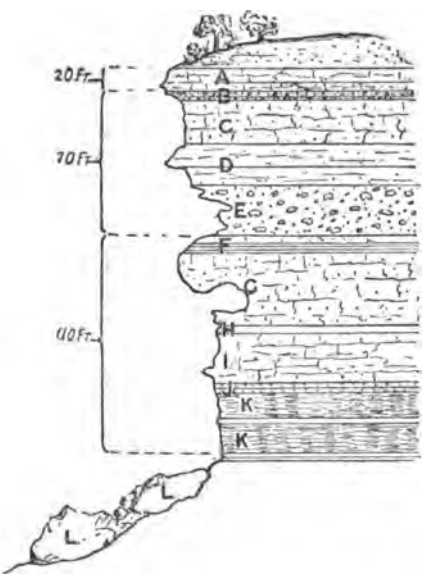
The members of this series are frequently full of whitish micaceous material, and are almost barren of fossil remains.

(*c*) *Upper Beds.*—These consist of very coarse sandstones lying upon fine shales, and passing above into alternating grits and conglomerates.

The maximum thickness is 200 feet in the immediate vicinity of Yalwal. The lower shales are frequently black by reason of much carbonaceous matter present.

One of the shale beds is eighteen inches in thickness, and is composed of masses of *Productus* and *Spirifers* remains held loosely together by soft cement.

SKETCH SECTION OF UPPER PORTION OF UPPER MARINE SANDSTONE CLIFFS, AT YALWAL.
Top of cliff 1,050 feet above Danjera Creek.



White sandstone.....
Red and Yellow sandstone.....
Black carbonaceous ....
Sandstones and Shales.....

Reference.

A. Coarse unfossiliferous sandstone.
B. Thin beds of conglomerate. Casts of *Spirifera.*
C. Coarse sandstone.
D. Red sandstone with *Spirifera.*
E. Conglomerate, consisting of large quartzite pebbles and granite slate, quartz, &c.
F. Sandstone filled with *Productus* and *Spirifera.*
G. Coarse sandstone with alum deposits.
H. Fossil horizon.
I. Soft black sandstones.
J. 16 inch band, thick with *Productus*, &c.
K. Carbonaceous shales.
L. Talus blocks.

The alternating fossil shales and coarse barren sandstones indicate rapid deposition with periods of more settled conditions when fossils flourished to such an extent as to form an integral part of the strata.

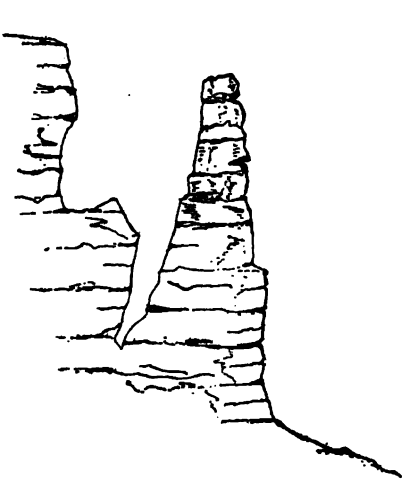
The conglomerates and grits consist of well rounded pebbles of rhyolites, granites, porphyries, and quartzites, and express the amount of degradation that the older strata were subjected to.

On superficial examination, the whole series presents lithological features analagous to those seen in the Hawkesbury sandstone of Sydney and its environments.

The Hawkesbury sandstone indeed forms the summits of the Cambewarra hills, just across the Shoalhaven.

Huge outlines of this upper series occur frequently. One represented below, and named the Chimney Stack, is 130 feet high, and but three yards in breadth at the summit.

"The Chimney Stack."



The fossils obtained from these sandstones have been named as follows, by Mr. W. S. Dun, Palæontologist to the survey :—

I. Lower Series.

Chænomya.
Platyschisma oculum. *J. de C. Sby.*
Spirifera. Sp. indeterminate.
„ tasmaniensis.
Martiniopsis subradiata. (Young).
Dielasma sp. indeterminate.
Mourlonia strzeleckiana. *Morris* (?).
Goniatites (Agathicras) micromphalum. (*Morris.*)
Martiniopsis oviformis. *McCoy.*
Aviculopecten cf. subquinquelineatus. *McCoy.*

II. Upper Series.

Martiniopsis oviformis. *McCoy.*
Productus Crachythærus. *G. Sby.* (very abundant).
Spirifera tasmaniensis. *G. Sby.* (Young).
Dielasma inversa. De Kon. Sp.
Spirifer duodecimcostata. *McCoy.*
„ convolutus. De Kon. =S. vespertilio. *G. Sby.*
Protoretepora ampla, *var.* Woodsi. *Eth. fil.*
Pachydomus pusillus. *McCoy.*
Spirifera, very indistinct, may be S. duodecimcostata. *McCoy.*
(This occurred at the summit of the cliffs near "The Gap.")

At Grassy Gully the basal beds contained :—

Platyschisma oculum. *J. de C. Sby.*
Pleurophorus gregarius. *Eth. fil.*
Spirifera duodecimcostata. *McCoy.*

(3.) *Devonian.*

This formation underlies the whole of the cap of Upper Marine sandstone.

The general trend of these older rocks is approximately that of the main divide of the Colony, viz., north and south. Small variations from this meridional direction occur, causing the strike to vary between N.N.E. and S.S.W., N. 10° W. and S. 10° E.

The dips, however, are exceedingly variable, the whole district having been thrown into a series of folds.

As will be seen on the appended map of Yalwal, there is evidence of a syncline in the centre of the field.

Lepidodendron beds, grits, and contemporaneous lavas occupy the upper part of this syncline.

The conglomerates found in the Jinkbilly Creek, which have a decided dip to the W.N.W. at 45°, are very possibly represented at the opposite side of the syncline by what is known as the Buck Reef, possessing a variable dip, but almost invariably in an easterly direction.

Conglomerates similar to the Jinkbilly variety occur some seven or eight miles above Yalwal along the Danjera.

Evidence of sharp folding occurs near the mouth of the Ettrema Creek. Originally, perfect arches stretched across the whole width of the creek at this spot. These have been partially removed by atmospheric agencies.

Of the rocks composing this Devonian series, highly siliceous varieties, consisting almost solely of quartz grains, are the most common. Generally they are finely laminated, but at times occurring in beds from twelve to eighteen inches in thickness.

With these are associated curly and siliceous slates, mudstones, spotted slates, and quartzites.

Higher up in the series are conglomerates in various stages of alteration. The pebbles are well rounded, and consist, for the most part, of fine-grained quartzites and claystones.

Intercalated with them are mudstones, shales, and claystones.

These pass upwards into felsite and basic lavas with tuffs, grits, sandstones, and fossil shales.

Eruptive Rocks.

(*a*) Rhyolite and dolerite lavas.

(1.) Field relations.—These lavas are so closely associated that they are here considered together, in so far as their field relations are concerned.

They persist in a N.N.E. and S.S.W. direction, over a distance exceeding twelve miles. What their further extension north and south may be, I am unable to say.

To the N.E. of Grassy Gully, on both banks of the Shoalhaven River, the rhyolites abut on the stream in precipitous manner.

Thence southwards, through Grassy Gully, the basic and acid lavas may be traced to the Upper Marine sandstone.

Reappearing at Yalwal Creek, the rhyolite is subordinate in amount to the dolerite, occurring only in small patches.

Here, however, the basic lavas make a great display, occupying almost the whole of Mackenzie's Station. These, however, appear to lie above the main rhyolite sheet.

The line of continuity of the lavas has also here been broken by the granitic intrusion.

Five or six miles above Yalwal, the associated rhyolites and dolerites appear to the south of the granitic masses, and then stretch for miles along the Upper Danjera, the rhyolites showing out beneath the Upper Marine sandstone as huge inaccessible cliffs, and the dolerites flanking them as steep wooded slopes.

The largest basic sheet is eight to ten chains in width, and may be traced for miles along the Danjera.

Beneath this again, in the bed of the creek, a second rhyolite outcrop occurs.

The acid lavas are pierced by the red granite in a remarkable manner, the intruding granite forming, throughout the rhyolite mass, an anastomosing system of lenticular veins and threads. The coarser rock partakes more of the nature of a huge apophysis than a boss, and roughly approximates to the strike of the rhyolite, piercing it in the manner above described for a distance exceeding two miles.

In Portion 1, Parish Yalwal, a small contemporaneous rhyolite occurs. It is of very limited extent, being some six chains in width and about 500 yards in length. It appears to have been intruded by one of the dolerite sills of the locality, and occurs among a great number of basic flows.

Contemporaneously with the more important *Lepidodendron* beds, several acid and basic lava flows occurred, accompanied by tuffs.

In Fletcher's paddocks, to the east of the Jinkbilly Creek, a similar condition of things obtains.

The great development of the dolerite sheets may be inferred from a glance at the map.

In some of the patches marked on the map as "dolerite lavas and tuffs, with associated sedimentary rocks," as many as a dozen basic sheets occur in less than a quarter of a mile traverse across the strike of these beds. These alternate with the *Lepidodendron* shales, felsite tuffs, tuffaceous mudstones, &c.

(2.) *Structures observable in the Field.*

(*a*) Rhyolites.

These possess conspicuous flow-structure. Well developed complicated flow-contortion markings are also common, imparting to the rocks the appearance of intensely folded laminated strata.

At Grassy Gully, the surfaces of the flow structure are persistently straight for considerable distances. In the process of weathering, these have become divisional planes, and the similarity to tilted laminated rocks is very pronounced.

Here, also, a certain amount of crushing is observable locally, the fragments being cemented by silica. These rhyolite breccias possibly bear some connection with the movements which caused the Grassy Gully reefs.

Along the Upper Danjera, porphyritic felspars are plentiful. Around these the flow structure is well shown, the felspars giving to the rhyolite an appearance similar to the "eye" structures of certain rocks.

The bands generally weather out in alternate black and white tints. Many of the black bands are not continuous in the lavas south of Yalwal as they are at Grassy Gully, but appear in the form of flattened spindles and cylinders with drawn-out ends.

The rock also develops locally as a black flinty-looking mass, filled with white inclusions.

A most interesting feature is the occurrence of large spherulites, varying in size from a pin's head to subspherical and ellipsoidal bodies two inches in diameter. The flow structure passes uninterruptedly through them. Concentric structure is plainly visible in some of the individual spherulites.

These interesting structures are described in rhyolites from other localities.

From Pambula nodular felsites have been described.*

Banded rhyolites occur at Bulladelah, containing spherulites over an inch in diameter. These belong to the Permo-Carboniferous.†

The spherulitic rhyolites of Yellowstone Park,** The Channel Islands,†† Hungary,‡ and other localities,‡‡ have been described in detail.

For the discrimination of structures, these rhyolites should be studied in the creek exposures. Here the selective action of the water has exposed their peculiarities. In the mass they are obscured, owing to the apparent homogeneity of the rock in fresh fractures, and its characteristically decomposed nature.

(*b*) *Dolerites.*—These consist of a series of dark-greenish black rocks, of high specific gravity, exhibiting most decided vesicular structure. The vesicles are frequently filled with products of decomposition, causing the rocks to become amygdaloids. The amygdules consist of soft chloritic products, quartz, calcite, and epidote. Calcite and chlorite are the most common of these secondary minerals.

The rocks have suffered great decomposition, long strings of epidote and serpentine crossing the rock frequently.

Very vesicular types occur to the immediate south-east of the cemetery, the east side of Sawpit Gully, and in front of the Public School.

Copper, associated with abundant zinc blende, iron, and arsenical pyrites, has been found in one of the dolerite flows. The occurrence is three miles above the village.

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* J. E. Carne. Ann. Rept. Dept. Mines N.S. Wales for 1896, pp. 111, 112.

† E. F. Pittman, Min. Res. N.S. Wales, 1901, p. 416.

** Iddings, vii Ann. Rept. U.S. Geol. Survey, 1888, 249–295.

†† J. Parkinson, Q.J.G.S., 1898, liv, 101–118.

‡ Cole and Butler, Q.J.G.S. 1892, xlviii, pp. 438–445 and references.

‡‡ Harker, Petrology for Students, 2nd Ed., 1897, p. 159.

(2.) *Intrusive dolerites.*

These possess great similarity to the contemporaneous basic lavas. They are generally fine-grained, greenish, and very compact rocks, devoid of vesicular structure.

It is probable that they are closely related in age to the higher members of the Devonian contemporaneous flows. They appear to transgress the bedding planes of the associated strata.

3. *Granites and microgranites (acid porphyries).*

The area occupied by the acid eruptives, as also their probable age, has been referred to in the notes on the general geology.

The occurrences are mostly of the nature of vertical bosses and huge tongues of quartz felspar porphyry. The main central mass may, however, be of the nature of a boss which has tilted the surrounding strata.

The rocks consist of red granites, quartz and felspar porphyries (microgranites), and aplite veins.

The granite is of medium coarseness, and is composed, essentially, of quartz and red felspar. Ferro-magnesian constituents are conspicuous by their absence. When present, they are of the nature of biotite or chlorite.

The porphyries consist of crystalline quartz and felspar in a pink granular base of the same minerals, the crystals being decidedly porphyritic towards the base. The quartz is of the smoky variety.

The unaltered quartzes, with their perfect contours set in a pink matrix, the latter only just discernible as granular in hand specimens, present a very fine appearance.

Miarolitic structure is well shown in a few varieties, the druses being very plentiful, the quartz and felspar being perfectly crystallised in the cavities.

The granitic and micro-granitic structures appear to shade off into each other by every gradation. As a rule, however, the granitic structure is confined to the more central portions of the larger masses.

Five or six miles above Yalwal the rock is typically a fine-grained granite, red in colour and miarolitic in character.

The porphyries of the Danjera Creek frequently weather out into pinnacle forms. As they become more granitic in character, typical granite weathering obtains, the sharp pinnacles giving place to dome-shaped hills.

About three miles above the village the rock is darker in colour, and is split up into huge slabs or tables by a uniform system of jointings possessing a south-east dip at 30°.

In Crawford, Johnson, and Hamilton Gullies, opposite the Homeward Bound battery, the rock approximates more to the quartz-felspar porphyries than the granites. The miarolitic structure is well marked.

The rock in the Yalwal Creek is also partly plutonic, and partly hypabyssal in habit.

Both varieties contain crystals of quartz; are almost devoid of ferromagnesian constituents; and are crossed by a series of narrow aplite veins, probably representing segregation into cracks before final consolidation had set in.

It is here, along the road to Grassy Gully, that the finest examples of the porphyries occur.

In the great mass occupying the whole of the lower four or five miles of the Bundundah (Right Arm) Creek, the rock posseses the same high acid percentage as the Danjera and Yalwal Creek granites, but the appearance of the rock is rather different.

At Silver Dell a fine granular base of quartz and felspar is present with quartz more or less in crystal form scattered throughout the mass, and imparting a semi-porphyritic character to the rock.

This granite has a dark vitreous appearance, owing to the great amount of cairngorm present.

A system of vertical jointings crosses this mass. These fissures are sometimes filled with greenish material, which appears to have permeated the country rock for a few inches distance from the fissures.

Zincblende and pyrites occur in abundance in these fissures, and are associated with silver and copper.

The amount of decomposition the granites have undergone is remarkable. It is difficult to secure a piece that will stand the process of preparation for microscopical examination. The felspars have become so kaolinised as to have lost almost all trace of cohesion, and in places the igneous nature of the rock is obscured.

The granite masses exposed in the Danjera and Yalwal Creeks by the partial removal of the Upper Marine sandstone cap, are identically the same as the granite eminences of the Permo-Carboniferous landscape, actual summits of which still lie beneath the sandstone.

Ever since that period the porous sandstone cap has readily permitted surface waters to attack the granite, without allowing the crust so decomposed to be removed. This would account for the generally rotten state of the granites, with the exception of that occurring at the bases of the deeper gullies.

Petrological Notes on some Yalwal Rocks.

The Basic Rocks.—An examination was made of specimens numbered 4,434, 4,436, 4,437, 4,439, 4,440, 4,442, 4,444, and 4,445 in the official register of rock specimens.

They represent rocks gathered from various portions of the field. In hand specimens they appear as greenish black compact rocks, varying from fine-grained basaltic varieties to coarse dolerites, and they may be grouped together as ophitic dolerites.

The base consists of lath-shaped felspars, with decomposed granular augite, iron ores, and needles of apatite. At times masses of exceedingly small felspars occur. The ground mass is generally finely holocrystalline. A glassy residuum, however, may have been present in certain instances, but owing to the great decomposition present, it is difficult to ascertain its existence.

Phenocrysts of felspar are rare, but in sections like 4,445, two crops of plagioclase are plainly visible, representing both intratelluric and effusive stages. The felspars are mostly of basic varieties, and are lath-like in habit. One slide represents large irregularly shaped phenocrysts, the contours being due to interpenetration growths. The first crop is represented by moderately sized plagioclase idiomorphs showing polysynthetic twinning. Broad twinning bands are present. Extinction angles, measured from the traces of the twinning planes, varied between 25° and 30°. This points probably to a basic variety, such as labradorite.

The second crop consists of abundant small lath-shaped forms.

Small idiomorphs at times appear partly enveloped by iron ores.

The ferromagnesian constituents are represented by augite, which is present both as phenocrysts and as grains in the base. All the members of the first crop are moulded on the felspars, thus giving rise to the ophitic

structure (Plate IX). Under the influences of decomposition, the phenocrysts appear to be granular, but examination under crossed nicols proves the masses connecting the felspars to be in optical continuity.

In the coarsest dolerite examined some of the augite automorphs are as much as ½ and ¾ inch in length, and contain as many as a score of felspar crystals in one individual.

These rocks are very difficult to examine in detail, the original structures being masked by alteration products.

The felspars are changed to opaque products, through kaolinization.

The augites are corroded, and appear as grains or strings, or irregularly shaped masses, greenish and brownish-green in colour. Serpentine and chloritic products are invariably present. Long strings of the former traverse the body of the rock. At times the serpentinous products form concentric radial fringes in the amygdules, after the fashion of agate structures. The augite also, in conjunction with the plagioclase, alters to saussuritic products. Epidote is abundantly represented in field examination, and calcite occupies the majority of the original rock cavities, and shows the characteristic rhombohedral clearage and bright polarisation colours.

Ilmenite is well represented in the base. The Grassy Gully dolerites show squarish to rectangularly shaped iron ores, and decomposition is sometimes seen taking place along traces of cleavage planes. One mass, resulting from alteration of the ilmenite, posseses high refractive index, is transparent, and shows pinks and greens of high order under crossed nicols. This variety of leucoxene may be related to sphene. Inclusions of apatite also occur in the ilmenite. Secondary quartz is also common.

The Rhyolites, as determined by examination of rock specimens, numbered 4,429, 4,430, 4,432.

These were selected from lava flows along the Danjera Creek and Grassy Gully,† and they represent rocks yellowish-brown to blackish in colour, showing marked fluidal and spherulitic structures.

Large porphyritic crystals of felspar are plentiful, scattered through a very fine base. Associated with the porphyritic felspar are biotite flakes much decomposed.

These phenocrysts represent the intratelluric phase of crystallisation. The felspars are generally rectangular, but at times show corrosion by the magma. Polysynthetic twinning is common. The twinning bands are narrow, and at times the extinction is slightly undulose. This may be due to excessively fine twinning. The felspar is probably an acid variety of plagioclase.

Peculiar forms of twinning occur in some of the felspars of the older crystallisation. Opposite quadrants extinguish and brighten simultaneously in polarised light (Plate X). The appearance is possibly due to Baveno twinning. Inclusions also occur which are opaque and white, and may be due to the decomposition of ilmenite.

The ground mass of the rocks shows under crossed nicols the peculiar dappled appearance of crypto-crystalline aggregates. Flow structures are invariably present as straight or wavy lines. Less frequently, they present all the appearance of minute foldings with sharp anticlines and synclines.

Perlitic structure is well shown between the straight lines of flow.

The "flow" phenomena are specially well marked round the felspar automorphs, the appearance being similar to the " eye " structure noticeable in certain rocks.

Spherulites were not observed in the perlitic specimens, but in the rocks showing contorted fluxion phenomena, well-formed spherulitic growths

† For Grassy Gully rhyolites, see also J. B. Jaquet, *op. cit.*

occupied the interspaces between the lines of flow. These are well developed and microscopic in size. This is known as the microspherulitic structure.

Along the bent lines of flow themselves the radiate growths occur in abundance. They do not start from a number of independent centres to form distinct spherical growths linearly arranged, but radiate from the contorted lines of flow themselves as axes. This is the axiolitic structure of Zirkel.

The finest examples of microspherulites, however, occur in a homogeneous looking felsite, in hand specimens almost devoid of the porphyritic element. The microspherulites themselves occur as patches of irregular shape set in a felsitic base. Under-crossed nicols the dark brushes of the tiny growths are arranged collinearly.

Some of these microscopic radiate growths have been replaced by quartz, secondary quartz is also very common, forming along lines of flow.

Iron oxide is common in red and brown stains.

Ilmenite is present, though not in great quantity. It is generally decomposed. Small zircons also occur.

Large spherulites are fairly common. They vary in diameter from $\frac{1}{8}$th to 2 inches. The lines of flow pass uninterruptedly through them.

The examination of these rocks points to a former vitrophyric condition, in which phenocrysts of an earlier period of consolidation occurred in a glassy base representing the effusive stage.

The base is cryptocrystalline (felsophyric) at present, but the great development of perlitic cracks points to former glassy conditions.

Divitrification in the case of the contorted flow-structure appears to have taken place as spherulitic and axiolitic growths. The non-association of the spherulites and perlitic growths is interesting.

Microgranites.—Determined by examination of rock specimens 4,428, 4,434.

The specimens described were chosen as typical examples from the Yalwal Creek, and the country rock of the lodes at Bundundah Creek.

These rocks are red to reddish brown in colour, and show idiomorphs of quartz and felspar plentifully scattered through a very fine but holocrystalline base. The individuals of this base are composed of quartz and felspar grains, which are roughly equidimensional, and show a tendency, in some instances, especially in the case of the felspars, to be idiomorphic. This matrix may then be described as hypidiomorphic granular. The rock is hypabyssal in character, and may be described as a quartz-felspar porphyry.

In the narrow aplitic tongues which pierce alike the dolerites and the rhyolites, the rock represents an almost simultaneous microscopic separation out of quartz and felspar. This is the micropegmatitic or granophyric structure. A decided tendency to graphic growth is observable in rocks from other portions of the field, the quartz showing characteristic six-sided skeleton crystals, the central portions being occupied by felspar.

The felspar of the first generation is represented by rectangular phenocrysts, $\frac{1}{8}$ to $\frac{3}{4}$ inch in length, much decomposed, and generally present as opaque white and pink kaolinised masses. In less decomposed examples, multiple twinning is frequently observed, pointing to plagioclase as the dominant felspar.

In rare instances, albite and pericline types of twinning, associated with quartz intergrowths, are exhibited by the same crystal. The crystals are coloured red and yellow with iron oxide, the edges being deeply stained at times.

The felspar of the effusive stage is clearer than that of the earlier periods, and has a great tendency to form granophyric growths with the later quartz.

The quartz of the earlier stage of crystallisation occurs as bihexahedral phenocrysts. Corrosion has, however, been set up, and inlets of the magma occur in the peripheries of the crystals These phenocrysts vary from $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter, measured across the hexagonal sections. Inclusions are numerous, and arranged linearly. The base becomes much finer in texture as it nears the point of contact with these quartz idiomorphs.

Ferro-magnesian material is present as a few irregularly distributed green patches. It is pleochroic, and probably represents some decomposition product of biotite. Iron ores occur as ilmenite, weathering into leucoxene. Iron oxide is abundant, sometimes as inclusions in the viridite. Apatite is present.

A noticeable feature in the Yalwal granites is the absence of large felspar phenocrysts so common in the granitic rocks of New England.

Another point of interest is that while the granites, or granitites, of New South Wales are generally basic in character, containing (especially in the porphyritic types) abundant plagioclase, biotite, hornblende, sphene, apatite, and zircons, the Yalwal rock is characterised by its high silica percentage and its lack of basic constituents.

Rock specimen, 4,429.—This is a rock much like spherulitic pitchstone in hand specimens.

The bulk of the rock is composed of concentric growths about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter.

The field evidence points to a tuffaceous origin.

Under the microscope, these structures are seen to consist of tiny flakes of hæmatite, with smaller quantities of limonite arranged concentrically, the long axes of the flakes being set parallel to the peripheries of the circles.

The base appears to be cryptocrystalline. The spheroidal growths are possibly expressions of weathering.

Economic Geology.

1.—*Alluvial Mining.*

The whole of the lower course of the Danjera and its continuance to the Shoalhaven as the Yalwal Creek contains alluvial gold, though not in great quantities

The majority of the gold found is fine in nature.

The whole course of the Yalwal Creek, as also many miles of the lower portion of the Shoalhaven, has been leased for dredging purposes.

The gold of the Danjera and Yalwal Creeks, being in a fine state of division, is difficult to recover by sluicing operations.

Saw-pit Gully (Plate III), a small watercourse draining the eastern part of the gold-bearing area, has, at various times, yielded a fair amount of gold.

The alluvial containing the gold consists of angular fragments of the associated Devonian strata and very large blocks of Upper Marine sandstone.

The gully is not of great age, the sandstone cap having but recently been worn through at this point, and the alluvial deposits of the stream postdate the degradation of the sandstone covering.

As the gold is, therefore, derived from the adjacent claims of the Caledonian, Bismarck, Usher, and Golden Quarry, one would naturally expect

to find it but slightly rounded. It is generally coarse at this spot, one nugget weighing as much as 3 or 4 ounces. Other specimens varied in weight from 15 dwt. to 3 ounces.

Gold to the value of £2,500 was extracted from the Sawpit alluvial in 1893.

Alluvial has also been worked at Grassy Gully, its discovery leading to the working of the Grassy Gully Reef.

(2.) *The Lodes.*

As far as at present known, no reefs with decided walls exist in the Yalwal district.

In 1883, Mr. Pittman,† Government Geologist, declared that the ore deposits were of the nature of impregnations in stratified rocks. Since then mining developments have done nothing further to indicate the existence of pronounced fissure veins.

The gold-bearing area proper is confined to a hard belt of rocks immediately south of the village of Yalwal, and occupies both east and west banks of the creek.

These sediments consist of quartzites, conglomerates altered in places to quartzites, schists and slates.

The greater number of workings occur on the eastern bank of the creek, those on the western bank being confined to a few blocks known as the Eclipse, Pinnacle, and Poor Man Claims.

Three large belts of conglomerate pass through the field.

One "makes" strongly through the Usher tunnel, across the Saw-pit Gully, and into the Golden Crown property.

Another and parallel belt emerges from the sandstone immediately to the east of the Homeward Bound open cut, thence through the eastern pegs of the Pioneer, across the Danjera Creek, as the "Buck Reef," Plate III, or "Mother Lode," and clean through the Pinnacle and Eclipse leases, leaving the latter property at the mouth of the No. 2 tunnel. Thence, with varying dip, it passes to the north.

These conglomerates consist of black and grey quartzite, slate and quartz pebbles, set in a fine siliceous cement. They have been so altered in places as to have lost all trace of their pebbly origin. The first stage in their metamorphism consisted in the reduction of the whole to a quartzite in which the matrix and enclosed pebbles are almost indistinguishable.

Further stages are marked by masses of impure quartz, all traces of pebbles having vanished.

The softer strata between the conglomerates, as also those beneath them have been subjected to great crushing.

All this line of country is auriferous in a greater or lesser degree.

Large low grade deposits have been found closely associated with the conglomerates, *e.g.* Golden Crown, Usher, Hidden Treasure, Pinnacle, and Eclipse claims.

These conglomerates are probably connected with less altered beds in the Jinkbilly Creek. In the latter locality, epigenetic agencies have not had nearly so much influence on the strata, the nature of the pebbles and the cement, as also the strike and dip being evident at a glance. Curious alteration products are observable in the Golden Crown and Pinnacle claims. A rock of felsitic appearance occurs in the lodes of these properties in great abundance, being as much as ten yards in width near the surface of the

† Annual Report, Department of Mines, 1883, 159–160. *Vide* also, The Mineral Resources of N. S. Wales, 1901, p. 59.

SOUTH END OF HOMEWARD BOUND OPEN CUT.

Pinnacle workings. It is, however, so soft that it can be scratched with the finger nail. It is whitish, brownish, and occasionally bright green in colour, being also in the latter case translucent, and of an oily appearance resembling pargasite.

Rarely it has the appearance of certain dolomites. In these cases it contains small radial aggregates.

Threads and lenticular bunches of quartz intersect it in all directions. Frequently also it is intimately associated with a dense, hard, siliceous rock resembling impure quartz.

Throughout these soft and hard silicate masses, large bunches of pyrites are capriciously distributed; there are also innumerable black strings representing oxidised pyrites.

Below the water level these formations contain huge masses of iron and arsenical pyrites, with white quartz. In the case of the Pinnacle, the Eclipse, and the Golden Crown, the "formation" is crossed with numerous slides, some of which have been mistaken for true reef walls, as "Reynolds' Hanging Wall"—a slide in the Eclipse.

The Homeward Bound, Pioneer, and Star leases represent the western portion of the auriferous area. The former two are worked as large "open cuts" or quarries, all the quarried matter passing through the batteries.

References to the diagrams shew the quarries to be contained in quartzites, iron-stained slates, possessing various dips, and traversed by slides.

The mass of strata worked for gold in the west is intersected with innumerable quartz-veins or "stringers."

Although these properties are not so intimately related to the conglomerates as the eastern leases, they may nevertheless be considered as associated with them, inasmuch as their strike is almost coincident with the western belt of conglomerate, and their distance apart is insignificant.

In the Caledonian property, a closer approximation to true veins is found. The strata here vary in dip from 30°–60° to the north-west and west-north-west. Narrow veins of chalcedonic quartz run across the "combs" of the country. These, however, appear to have no depth, and, as far as at present proved, pinch in and out with wonderful rapidity.

The quartz of the field is generally very impure, being for the greater part of the chalcedonic variety, bluish to grayish in colour, and weathering into products having the appearance of whitish and yellow clays.

Opaque white quartz occurs associated with the pyritic masses of the conglomerate area.

The bulk of the soft material in the lodes appears to be derived from crushing of the strata.

The only important constituent of the lodes is gold.

It is marked by its occurrence in an extremely fine state of division. Similar occurrences are noted from Wyalong* and Pambula.†

Free gold occurs in the oxidised zones, but, as far as at present known, not in the sulphide zones. The pyrites of the sulphide zone yield on assay from 2 to 24 dwt. of gold per ton, the bulk of the mineral being of poor quality, rarely exceeding 2 dwt. per ton. This information was supplied by the mining men of the field.

The surface gold was contained in a variety of gossan, and was at times coarse in nature. Throughout the lode the gold occurs in irregularly distributed patches, and as films coating divisional rock planes. Very often no trace of the gold is to be seen in the solid rock between these gold-covered jointings.

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* J. A. Watt, Min. Resources, No. 5, p. 19. † J. E. Carne, Ann. Rpt. Dept. Mines, 1896, p. 116.

From this it seems evident that the sulphides contained the gold, and that surface waters reduced the auriferous pyrites to iron-oxide, free gold, and various soluble products.

At Grassy Gully the auriferous belts occur in felsite formations, traversed by thin quartz veins. Gold is found in a finely-divided state on the joint faces of the crushed felsite.

Three miles to the north of Yalwal, along the Yalwal Creek, the granite has surrounded a mass of basic rock. A white variety of quartz occurs in the granite near the junction of the two rocks. Silver has been found at this spot.

In the Right Arm (Bundundah) Creek, silver, lead, and copper have been mined for in granite.

The minerals occur in joints and fissures, which are traceable over considerable distances in an approximately north and south direction.

The vein material is at times greenish in colour.

Copper associated with zinc-blende and pyrites has also been found in the dolerites. Granitic dykes occur in close proximity to this lode.

The Genesis of the Deposits.

It is very probable that the intrusion of the Carboniferous (?) granites and micro-granites formed the most important factor in the folding of the Yalwal district.

These foldings were accompanied by intense local deformations

The axes of the foldings coincide with the strike of the beds, and the ruptures forming the lodes appear to follow the lines of greatest weakness. This is plainly seen in the Homeward Bound, Pioneer, Pinnacle, Eclipse, and other auriferous belts.

The cooling of the eruptive masses was also attended with crushing owing to the shrinkage of the mass.

The soft green-and-white lode products are, doubtless, due to the crushing of the softer strata against the harder belts, the nature of the material so derived being modified subsequently by mineralised waters.

Innumerable shrinkage cracks were developed in the strata, which had been twisted into sharp anticlines and synclines. Into these cracks quartz, auriferous pyrites, and other minerals were introduced by circulating waters.

The faces of the joints and faults were also charged with gold in the same manner.

The Caledonian deposits admit of a similar explanation, although here the "reefs," which are larger than the "stringers" of the Homeward Bound, do not follow the strike of the country, but break across it. They are, however, very limited in extent, and represent slight ruptures in the harder and more compact rocks, which crossing the "combs" of the country, were allowed to remain open until filled with chalcedonic quartz. It is very probable that these lenticular masses of chalcedonic quartz, containing rich gold patches may exist in other portions of this belt of country. A single tunnel cannot be expected to prove the ground entirely, as these small veins pinch in and out with great rapidity.

Similar conditions appear to have obtained at Grassy Gully. Here, however, the disturbed rocks consist of rhyolites and dolerites.

Grassy Gully reef appears to lie along a line of crushed rhyolite. The fragments resulting from crushing have been cemented by quartz, and the breccia itself is traversed by very small quartz veins.

The general appearance is that of local crushing, which took place along meridional lines.

This brecciation in certain cases may be due to the opening of fissures, and subsequent movement of the walls on one another.

Other occurrences are at times suggestive of "crush breccias," the fragments being subsequently cemented by silica and tiny veins of chalcedonic quartz developed throughout the mass.

The gold occurs in joints throughout the formation of crushed rhyolite, and is found both in the igneous rock and in the quartz.*

It is associated with pyrites and occurs in a very fine state of division, as at Yalwal. Rich specimens at times consist of rhyolite masses having thin coats of gold on one or more sides determined by rock joints, the rock between the cleavages being absolutely barren of the auriferous material.

It appears then that the Yalwal district was much contorted, that the contortion or movement was of considerable duration, during which fissures opened along the lines of maximum weakness (the axes of the folds) and were closed again, a grinding action ensuing, the outward and visible signs of which are the various lode formations; and that innumerable cracks sent their tiny ramifications through the mass as a result of the above mentioned forces and also of the shrinkage due to settling down of the disturbing agents; and that highly mineralised waters circulating through the mass deposited gold bound up in pyrites.

Description of Mining Properties.

The Pinnacle.

This claim, known also as No. 1, lies on the north and south line of the crushed formation that follows the belts of conglomerate. The lode is exceedingly variable in width, and is apparently due to the metamorphism of the associated conglomerates and intercalated beds. The alteration products at times have the appearance of felsites. They can, however, be scratched with the finger nail. Quartz occurs throughout this "formation" generally as white opaque varieties, in irregular patches, as though filling cracks in the soft crushed mass. Throughout the lode, also, black oxidised pyritic bunches occur in the same irregular manner. These, at about a depth of 100 feet from the cap of the lode, make into large bunches of pyrites. Their assay value is very low. In other places the formation consists of a dense, opaque, iron-stained siliceous material, resembling an impure quartz.

The country consists of mudstones, shales, quartzites, slates, and siliceous schists, having a general north-east dip, varying from 30° to 50°. This dip, however, exhibits numerous variations from the general north-east direction, indicative of minor crumplings superimposed on a general fold.

The methods of working adopted consisted of excavating the top to a width of nearly two chains, and a corresponding length along the line of strike, and a depth of about fifty feet. A floor was here left, and beneath this again another large excavation was made, connected with the upper workings by passes. This bottom chamber narrows at about 100 feet below the cap to eleven yards in width. Two tunnels are driven into it from the hillside, near the battery.

The upper one is some 100 feet in length, and passes through beds containing *Lepidodendra.*

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* J. B. Jaquet, Records Geol. Survey, 1900, vii., p. 17.

The lower one, some 60 yards in length, is the main outlet for the ore passing to the battery, and is cut out of the creek bluffs at 45 feet above the water. This lower tunnel has been continued through the workings for another 100 feet to prove the country west of the lode.

The battery in use consists of fifteen head of stampers, 800 lb. each in weight. It is attached by gearing to a Robey engine of 20 h.p., worked with a multi-tubular boiler. A Jacques rock-breaker is employed, as also automatic feeders. Two Berdan pans and Huntingdon mills were originally in use, but have since been discarded.

The gold returns were furnished by Mr. J. Sievewright, and represent a few of the better yields from this, the pioneer property of the field.

Gold Returns.

Date.	Tons crushed.	Oz. of gold.
May–Sept., 1872	.....	118
Nov., 1872–March, 1873	80	120
1874	220	330
1875–1878	Returns lost.	700 (?)
May–Dec., 1878	315	382
Jan.–Feb.,1879	53	115
April–July, 1880	280	670
March–Nov., 1881	1,406	282
Feb.–Oct., 1882	341	69
Total from 1872–1882	.....	2,786

The Eclipse.

This property, also known as No. 2, joins the Pinnacle to the south, and appears to be continuous with it. The workings of both properties open freely into each other, and give the idea of a series of gigantic caves, superimposed one above the other, and connected by narrow passages.

The uppermost workings exist (as described for the Pinnacle) in the form of an open cut, terminated below by an irregularly shaped floor. Below this, however, still larger caverns exist, with attached side caverns, and below this again another series of chambers.

Some of these are as much as fifty or sixty feet in height, fifty feet in length, and thirty to forty feet in width. The total depth of the Eclipse series of chambers is 160 or 170 feet. Recently mining operations have been revived in this property, and the top floor, in the immediate vicinity of "Reynolds' Hanging Wall" (a joint-face mistaken for a true fissure wall), has been blown away by explosives, and exposes a cavern 100 feet in depth. Some of the individual shots used in blasting the material, forming the floor between the uppermost and middle chambers, brought away over 100 tons of stone.

The whole of the material left by stoping operations presents a dangerous appearance. Fragments of rock, several tons in weight, project loosely from the walls. Under the present management, however, these are being removed, and the workings will henceforth be safe to work in.

PINNACLE AND ECLIPSE CLAIMS. FROM THE NORTH.

What has been said concerning the Pinnacle applies with equal force to the Eclipse, except the presence of the soft-green crushed material. The country is harder in the Eclipse than in the neighbouring property.

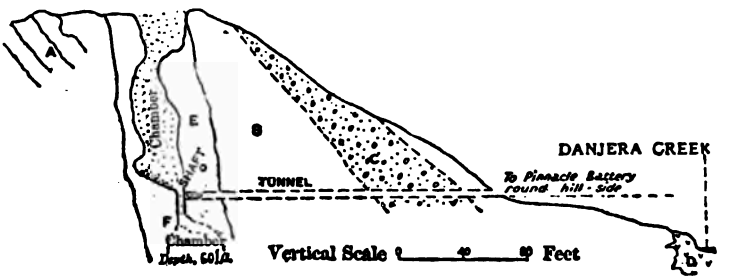
The workings are also much deeper.

A large chamber, fifty-five feet deep, and of almost equal length, exists in the Eclipse below the bottom level of the Pinnacle. Two shafts, also some sixty feet deep, were sunk in the lower level. Much of the work was carried on in solid pyrites and opaque white quartz.

A small tunnel has been driven near the top of the workings, to afford an outlet for the ore of the open cut.

A lower tunnel was driven in the hill-side to prove the northern side of the property.

SKETCH SECTION ILLUSTRATING THE METHOD OF WORKING "THE ECLIPSE MINE."



Reference.

A.—Contorted slates.
B.—Hard siliceous rocks.
C.—Altered conglomerates.
D.—Intrusive dolerite.
E.—Much oxidised pyrites.
F.—Much arsenical and iron pyrites.

Note.—The Pinnacle tunnel, as indicated above, is projected into the same plane as the Eclipse workings. There are no defined boundaries to the lode as shewn in the section.

An almost circular route was taken with the open cut as goal.

This tunnel was used to convey the ore to the battery.

At present, however, the two properties (Pinnacle and Eclipse) have been amalgamated, being the property of Mr. Alex. Hay. The stone in the vicinity of Reynolds' Hanging Wall is broken down, passing over a large tip in its fall into the Pinnacle claim, whence it is trucked along the lower tunnel (Pinnacle) to the Eclipse battery, as the Pinnacle battery, a larger and much better plant, is slightly out of repair.

The Eclipse battery [Plate VI] consists of ten head of stampers, each 600 lb. in weight. Punched screens and copper amalgamating plates are in use. The battery is connected with a portable Robey engine, of ten horse-power, by bevelled-gearing.

The tailings passed into settling pits, and were then turned into vats to undergo the cyanide process. Two leaching vats were used, each ten feet in diameter, with a working depth of four feet and a capacity of nine tons. This plant is not used at present.

Good crushings have been obtained from the mine during the last few months.

The following gold yields of the Eclipse Mine were kindly supplied by Mr. John Maclean, of Nowra, and date from 15th May, 1878, to 14th July, 1889 :—

Date.	Tons Crushed.	Oz. of Gold.	Amount.
Results as per Mint Proceeds during Suffolk's Tribute.			
			£ s. d.
14 May, 1878, to 30 December, 1878	.....	.....	155 1 0
14 March, 1879, to 15 April, 1879	.....	.....	92 19 0
Results obtained by Eclipse Gold-mining Co.			
October, 1879, to 22 December, 1879	161	264·73	886 14 0
14 February to 23 December, 1880	376	573·84	1,895 3 0
22 July „ 22 „ 1881	1,034	801·00	2,795 3 0
4 March „ 10 August, 1882	851	307·66	1,015 10 0
27 June „ ——— (?) 1883	160	230·00	578 13 0
4 April „ ——— (?) 1884	100	95·06	330 0 0
10 November „ ——— (?) 1885	.....	.....	120 19 0
6 August „ ——— (?) 1886	.....	.....	502 2 0
14 June „ 14 December, 1887	.....	.....	1,751 11 0
20 January „ 14 November, 1888	.....	.....	703 7 0
27 March „ 26 July, 1889	.....	.....	964 0 0
Total till July, 1889	.....	.....	£11,543 2 0

The following averages represent a nine months' continuous crushing, *i.e.*, the averages of the monthly percentages of the total amount of stone mined and treated during that period (prior to 1889) :—

	s.	d.	
Mining	1	8½	per ton.
Crushing	1	7½	„
Fuel	0	9⅝	„
Stores	1	0$\frac{1}{12}$	„
Approximately (mine to Mint)	5	2$\frac{11}{12}$	

The Pioneer Claim.—This property consists of three open cuts of large size, a lower tunnel 950 feet in length, an upper tunnel some 450 feet in length, and a fine battery situated about twenty-five feet above creek level.

After being worked for a while at the surface, shafts were sunk on supposed reefs. The gold, however, being discovered in "stringers" throughout the country, it was found advisable to adopt the quarry or open cut system.

In all there are three open cuts, Nos. 1, 2, and 3.

Nos. 1 and 2 open cuts are about fifty to sixty feet deep in very unsettled country, the strata having suffered much from crushing.

The material from these open cuts was conveyed to the battery by means of a short tunnel driven in from the hill-side, and by a pass connecting with the main tunnel.

No. 3 open cut is larger than Nos. 1 and 2. It is continuous with the Homeward Bound workings, and its floor is about fifteen feet lower than that of its neighbour. It is also of more recent date than the other Pioneer workings. The ground is also more settled, the beds having a general west-north-west to north-west dip, varying from 30° to 40°.

A fault runs along the eastern boundary and disappears in the wall about half-way along the quarry's length. The beds of this open cut may be seen to cross the north and north-west ends of the Homeward Bound open cut.

PIONEER BATTERY. FROM THE NORTH.

Mr. J. Hanson purchased this property in 1890, and became sole proprietor He drove a tunnel into the hill from a spot not far removed from the site of the present battery. This tunnel was driven with the double object of conveying the stone to the battery and proving the existence of any lodes.

Its course is straight for some 8 chains, thence under the open cuts its course is sinuous. It is 130 feet below the floor of No. 3 open cut, and passes connect it with the various workings.

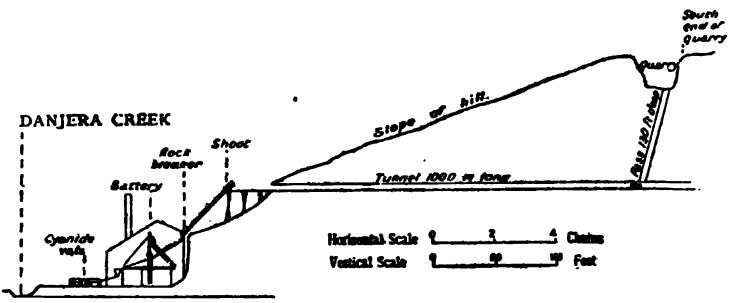
The strata passed through consists of curly and siliceous slates, quartzites, etc. Small quartz veins cross the directions of the bedding but appear to be only slightly auriferous.

On completion of the tunnel in 1891, a forty-head battery was erected (Plate VII). Each stamper is 900 lb. in weight, and works at from sixty-five to seventy drops per minute. Punched screens, and copper plates (twelve to fifteen feet in length) are in use. A giant rock-breaker, fifteen inches by nine inches, is employed as also Challenge automatic feeders.

The battery is driven by gearing from the engine, which is of the compound condensing type of eighty I.H.P., and giving seventy revolutions per minute.

Two boilers are in use, made by the Otis Co. of Melbourne from Batcox and Wilcox pattern.

SKETCH SECTION OF "PIONEER" WORKINGS, ILLUSTRATING THE METHOD OF SENDING ORE TO MILL AND CYANIDE PLANT.



The diagram illustrates the method of conveyance of ore to the battery. The stone is sent down a pass 130 feet in depth to trucks running on a slightly inclined tramway to a shoot, whence the ore is conducted into the rock-breaker and thence to the battery.

The cyanide plant which was erected in February, 1898, is worked on the New Zealand plan, and consists of three solution tanks. Two of these are each of fifteen feet diameter and six feet working depth. The other is ten feet in diameter and six feet in working depth. The leaching vats are five in number. Four of these are twenty feet each in diameter and of four feet working depth. The capacity of each is sixty tons. The remaining vat is fifteen feet in diameter and of forty tons capacity. These vats are fixed on a concrete foundation. No upward current of water is used whereby to minimise the deleterious effects of the slimes, but instead Spitzkastens are attached to the end of the amalgamating tables.

Lime is employed as the neutralising agent, 2½ to 5 lb. being used to each ton of tailings. Three precipitation boxes are used to recover the gold. A complete assay plant is attached to the battery.

The gold returns for individual years are not available, but the total amount won from the inception of mining operations until the end of August, 1895, was £24,000.

In 1896, 9,664 tons of stone were crushed for a yield of 454 ounces of smelted gold.

Since that time very little mining has been carried on.

Homeward Bound Claim.

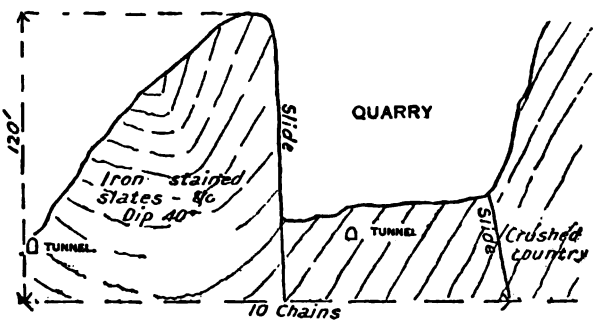
This property is the only one on the field that has been worked continuously for the past three years.

The property consists of two gold leases, containing nearly fifteen acres and two mining tenements.

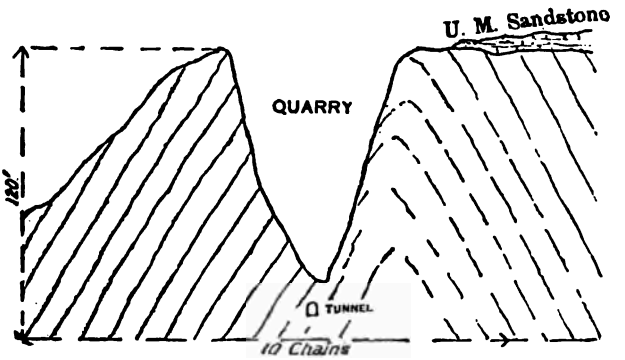
About the year 1872 the surface of the present Homeward Bound Claim was prospected for gold. Shafts were then sunk on supposed quartz veins and stoping afterwards carried on to such an extent that the various workings became connected. The cap was then broken down, and mining operations have since been confined to the formation of a large open cut.

A glance at the plan and sketch sections of the workings reveals the varying dips of the strata.

SKETCH SECTIONS ACROSS "HOMEWARD BOUND" CO.'S QUARRY.



Section from W. to E. through middle of quarry; dip slightly exaggerated; no reefs are visible.



N.N.W. and S.S.E. section through S.W. corner of quarry, showing possible anticline, signs of which are visible from the south; no reefs showing.

At the north-west and north-east extremities, the prominent dips noticeable in the "Pioneer claim" obtain, viz., north-west to west-north-west at angles varying from thirty to forty degrees. The dip then rises rapidly to the south-west and near a fault on the western boundary is north-west at sixty-five degrees.

At the extreme south-west portion there is evidence of a small anticline among the slaty rocks, the beds at this spot dipping in an easterly direction at thirty degrees.

A slide (fault) occurs alongside the eastern wall of the open cut. This also passes into the "Pioneer" claim and has influenced the beds there. The ground immediately to the east of this fault is much crushed, the rock dips not being recognisable.

The open cut is rectangular in plan. At the surface the length is about four chains, and the width three chains.

The batter of the open cut is about sixty degrees, although in places slides have caused the walls to assume an almost perpendicular appearance.

An anticline occurs between the open cut and the mouth of the tunnel.

The open cut is 100 feet in depth at the southern end, but tapers away to the north owing to the hill slope.

Throughout the whole of the excavation there is no sign of a decided reef, the gold occurring in small quartz "stringers" scattered in all directions throughout the country.

In 1891 a tunnel was driven into the hillside to facilitate the conveyance of the ore to the battery below.

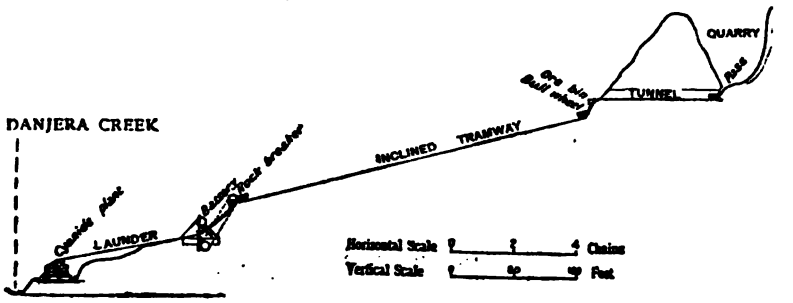
The walls are broken down and trucked to one of the several passes in the floor of the workings; thence they pass to the tunnel twenty feet below and are trucked by horses to the ore bin. Here a bull wheel enables the trucks to be sent down an inclined tramway by the force of gravitation alone.

The inclination of this tramline is from eleven to fifteen degrees, and its length is 200 yards. The stone is tipped into the rock-breaker and passes thence through automatic feeders into the battery.

The tailings are conveyed directly from the amalgamating plates by a launder to the cyanide plant.

This method of procedure is explained by the sketch section.

SKETCH SECTION SHOWING METHOD OF SENDING ORE TO BATTERY BY GRAVITATION, "HOMEWARD" BOUND G.M. CO.



The battery in use consists of forty head of stampers, each 900 lb. in weight, also ten head of stampers, each 700 lb. in weight. The average speed is seventy-two drops per minute. Punched screens (190 holes to the

inch) are in use and copper amalgamating plates. (Plate VIII.) The battery is driven by a horizontal, high pressure, non-condensing engine, having a cylinder of twenty inches diameter and a stroke of forty inches.

The two boilers are multitubular, twelve and fifteen feet respectively in length, and six and a half feet in diameter.

A Worthington Duplex pumping engine is employed.

The following notes on the cyanide plant were supplied by Mr. A. F. Mixner, General Manager of the "Homeward Bound" Gold-mining Company.

The vats (leaching) are nine in number having a total capacity of 350 tons. Five vats are of thirty tons, and four of fifty tons capacity.

The diameters are twelve and fifteen feet respectively and the working depth of all seven feet three inches.

Owing to the hilly character of the locality the plant had necessarily to be constructed with the solution vats and zinc precipitation boxes on the high ground, and by this arrangement the solution has to be pumped to the zinc boxes for the extraction of the gold. The pump works the three solution valves (alkaline wash, strong and weak solutions) with the one piston, and the amount of solution required to be lifted is regulated with bye-passes connecting the delivery pipe and the collecting pumps, so that the solution running with the greatest strength governs the speed of the pump) and the bye-passes are opened to such a degree as to compensate for the suction of the other two. The tailings are conveyed to the cyanide plant by a wooden launder and iron pipe. From the main sand pipe, each vat is connected by a separate pipe leading into a distributor, the height of the sand launder being nine feet above the vats. Under the launder the solution pipes are placed, each vat having its own connection with the same, and in such a way that the solution can be either applied to the top or forced in from below, this being one of the advantages gained from the situation of the solution vats.

The solution connections are simplified by the arrangement of three-way valves leading from the main, and also a two way valve at the side of each vat, acting so as to divert the current of the solution either up or down into the vessel. This solution pipe is also connected with a three inch water main so that the water can be applied in a similar manner.

Great difficulty was at first experienced owing to the slimy nature of the pulp, and it has been found advantageous to apply an upward current of water whilst the vat is being filled. Thus the slimes are borne upwards over the vat rims, and a free leaching pulp remains.

The treatment.—The principle of the process is continuous percolation.

Filling takes place at the rate of one ton and a half per hour.
Draining water from tailings occupies eight hours.
Treatment with alkaline wash occupies twenty-two hours.
" " strong solution occupies seventy-two hours.
" " weak solution occupies ninety hours.
Draining after weak solution occupies eight hours.
Discharging residues occupies three to four hours.

The strength of the strong solution varies from ·26 to ·3 per cent. of potassium cyanide (KCY). That of the weak solution of potassium cyanide varies from ·14 to ·18 per cent.

HOMEWARD BOUND BATTERY AND CYANIDE PLANT.

The alkaline wash required is made up with ·8 lb. alkali to the ton of tailings treated. The effect of this wash is to neutralise the natural acidity of the tailings.

After the alkaline wash the strong solution is applied, and then the weak.

The clean-up is conducted in the ordinary manner by rubbing the deposit off the zinc filament, drying and roasting with ten per cent. of nitre, then fluxing with borax, soda, bicarbonate and manganese dioxide, under which treatment a rough bullion of a value of fifteen shillings per ounce results.

This is refined and is forwarded to the bank having an average value of about £3 per ounce, whereas the native gold of the mine is worth about £3 5s. per ounce. The alloy is silver.

Generally speaking the amenability of the ore to cyanide treatment allows of a very cheap method of treatment. This smallness of cost is further accentuated by the fact of the porous nature of the material acted on, allowing a coarse (120 holes to the inch) screen to be used.

The precipitation in the cyanide treatment is by zinc filaments. Four boxes are in use, each 13 feet 6 inches long, 2 feet 6½ inches wide, and 2 feet 2 inches working depth. There are nine working compartments in each.

The consumption of zinc per ton of tailings actually treated is ·75 lb.

The average percentage of extraction by amalgamation is 40 to 44 per cent., and the extraction of gold from the tailings by cyaniding ranges from 66 to 84 per cent., according to the value of the material under treatment, and this value varies from 30 grains to 4 dwt. of fine gold per ton.

The plant is almost automatic, one lad in each shift doing all the work.

A considerable space has been devoted to this cyanide treatment at the Homeward Bound, but the simplicity and cheapness of treatment coupled with the fact that the cyanide plant saved the mine when recovery by amalgamation was rapidly approximating to a negligible quantity, justifies the extra space given up to its description.

The percentage of extractions is:—Milling, from 15 to 47 per cent.; cyaniding, from 50 to 84 per cent. The cost of treatment per ton at this mine is as follows:—

	s.	d.
Mining	2	0
Explosives		4·68
Fuel	1	6
General Stores		1·90
Up-keeps and Repairs		9·16
Milling	1	7
Cyaniding (including smelting, refining, assaying, etc.)	3	0
Total	9	4·74

The foregoing figures are averaged from 30,000 tons of stone treated. Twenty-eight men are employed in the mine; in the mill three men and three boys, three stokers, and two others.

Gold returns of Homeward Bound Mine.

(1.) From crushings dating from 1882–1889, with a 10-head battery.

	Silver.	Gold.
	£ s. d.	£ s. d.
June 1—August 29, 1882	6 18 4	575 18 11
March 4—December 20, 1883.....	29 12 3	2,555 17 9
January 6—October 3, 1884	26 1 6	2,051 7 6
May 8—October 3, 1885	68 17 5	5,133 11 9
January 15—December 24, 1886 ..	.....	3,564 7 0
February 18—December 6, 1887...	60 13 11	6,105 10 0
January 10—December 6, 1888 ...	25 14 3	5,478 2 11
February 7—July 24, 1889	.....	2,196 2 3
Totals	216 18 8	27,650 18 1
		216 18 8
Total	.....	27,867 16 9

(2.) Later returns, dating from 1890–1900.

June, 1890—April, 1897 (from August, 1894—February, 1897, the mine was not worked owing to litigation) 9,804 oz 10 dwt. 20 grs. of gold were recovered. Average value £3 4s. 9d. per oz.

From September, 1898, to December, 1900, 37,898 tons crushed, and 13,871 tons cyanided. The gold won by amalgamation amounted to 3,723 oz. 2 dwt. 20 grs. (Standard gold) 762 oz. of silver were also won.

From cyaniding, 1,570 oz. 5 dwt. 15 grs. of gold recovered at value of £4,229 8s. 3d.

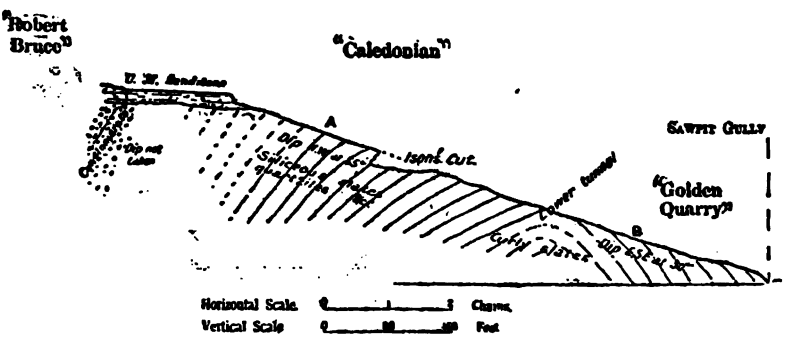
The Caledonian Property.

This is the claim from which all the sensational gold finds have come. The property is also known as G.L. 20, and is twelve acres in extent. The Permo-Carboniferous sandstone forms a cap over the whole claim except over a small patch at the north-west corner.

The workings consist of two tunnels, one being 100 yards in length, and a few open cuts about a couple of yards in width, varying in length from one to four chains, and in depth from ten to fifty feet.

It will thus be seen that the ground is by no means proved as yet.

SKETCH.—SECTION ACROSS THE CALEDONIAN PROPERTY FROM THE ROBERT BRUCE CLAIM E.S.E. TO THE GOLDEN QUARRY CLAIM AND SAWPIT GULLY.



NOTE.—The ground from A to B shows numerous irregular fissures (especially near the summit of the anticline) filled with chalcedonic quartz.

The gold is confined to small chalcedonic quartz veins crossing the combs of the country. The enclosing strata consist of siliceous and curly slates, quartzites and conglomerates dipping north 60° west at angles varying from 15° to 65°.

In the lower tunnel the strata dip in opposite directions at the two ends of the drive. This shows the existence of an anticline immediately to the east of the workings.

The gold occurred in patches of exceptional richness, as explained by a perusal of the gold returns.

The open cuts, whence the gold was won, were driven on small veins. They are named as follows:—

1. *Sandeman's Cut.*—This is 100 feet in length, thirty feet in height, and having a direction of 220°.

The gold was found in "stringers" of bluish and whitish quartz of felsitic appearance. The underlay of the vein is about 10°.

2. *Underwood's Cut.*—This is one chain in length and about thirty feet in depth. Nearly £40,000 of gold were said to have been extracted hence.

3. *Ison's Cut.*—Occurs one chain north of Underwood's Cut. The length is some four chains, and it has a direction of 230°.

A line due north and south connects the mouths of the various cuts.

Gold Returns.—Only a few of the better returns were obtainable, the total amount of gold not being known—

	£
1892. (Three months' crushing)	3,500
1895. 27½ tons for 1,487 oz.	4,833
1895. 1¼ „ 750 „	2,438

Original company since that time obtained more than £6,000 worth of gold in a few months.

It is also stated that in the year 1895, 4 tons of stone yielded 1,664 oz. of gold.

The Star.

This claim was taken up in 1883 by a Nowra syndicate.

It occurs on a very rough sideling.

Three tunnels have been driven at various levels into the hillside, with an almost due east direction. They are driven as closely as possible to the Homeward Bound property, and they lie vertically one above the other.

The upper one is 200 feet in length and 400 feet above the creek, the middle 350 feet in length, and the lower 450 feet long.

This lower tunnel is driven almost at the creek level.

In the two upper drives a little gold was found.

The country consists of siliceous slates principally, that show an easterly dip. Small quartz veins cross the property.

This claim lay idle for years. In 1900 it was taken up by Mr. H. Martin, and subsequently amalgamated with other leases belonging to Mr. A. Hay.

In September, 1900, four tons of stone were crushed for a return of 5 oz. 7 dwt. per ton.

Shortly afterwards, a parcel of 100 tons was made up and crushed at the Pioneer battery. The yield was a little less than 10 dwt. per ton.

The Golden Crown.—This property, also known as G.L. 1., occurs in much altered country in close association with the conglomerate belts. An intrusive sheet of dolerite occurs immediately to the east.

The country has been subjected to great crushing and extreme silicification, the latter possibly through the agency of heated mineral waters.

The soft magnesian silicate rock with the appearance of felsite is of frequent occurrence. Here much of it occurs in patches of bright green translucent to almost transparent masses.

The workings consist of an open cut at the base of which is a shaft about ninety feet in depth. A tunnel nearly sixty-five yards in length was driven in the hill from Sawpit Gully to connect with the various workings.

Great quantities of pyrites occurred in the lower portions of the workings.

The Usher.

This property is known also as G.L. 17. It contains a tunnel 230 feet in length driven towards the western boundary of the lease. After passing through slates, a belt of soft conglomerate was encountered.

A shaft was also sunk on the hill side to a depth of forty feet. The mass of the material driven through consisted of oxidised pyrites, associated with quartz and conglomerate

The pyrites on assay are said to yield 24 dwt. per ton.

Golden Quarry (Nos. 1 and 2).

G.L. 27 and 28. Golden Quarry No. 1 has a shaft sunk thirty-three feet east of G.L. 19 and thirty-four feet deep. A cross-cut fourteen feet long was driven on a formation six feet in width.

A tunnel also 208 feet in length was driven west from the level of the gully.

In 1896, 113 tons of stone extracted from both claims were crushed for a yield of 188 oz. 8 dwt. of gold.

The Victory.

The country is much altered, intense silicification having occurred in the slates and other rocks. Many of the strata now consist of quartzites. A hard belt of country occurs in this claim which is being mined for gold. A tunnel has been driven through the property for a distance of 500 feet.

This property is situate between the Pioneer and Pinnacle Claims.

The Poor Man.

This claim was prospected for gold in 1880, and then taken up. The country consists of narrow belts of quartzites, slates, and shales, much bent, crushed, and faulted.

The workings consist of a large open cut, and a tunnel a couple of chains in length.

Gold was found on the faces of the rock joints. The occurrence of the metal was extremely irregular, as in the cases of the other Yalwal claims.

No account was kept of the better gold returns. In 1896, 311 tons of stone were crushed for 75¼ oz. of gold.

Other minor Properties.

These consist of properties, such as Baberton's lease, Sir Julian's Leg, The Albion, The Coolongatta, The Daydawn, and The Bruce.

Baberton's Lease—This occurs in crushed and faulted quartzites and shales to the north-west of the Poor Man. An open cut was started.

The Albion (G.L. 26).—This contains a drive, 130 feet long, and also a cross-cut. Much pyritic material was found here.

The Coolangatta (G.L. 39) gave good prospects, and contained much pyrites.

The Daydawn (G.L 23).—A tunnel, 100 feet long, has been driven in at the level of Sawpit Gully. Pyrites occurred in great abundance, with an assay value of 8 dwt.

The Bruce (G.L. 18 and 19).—This property adjoins the Homeward Bound to the east. Very little work has been done. The country is similar to that of the Homeward Bound.

In 1896 a parcel of 18 tons was crushed for 16¼ oz. of gold.

B. Grassy Gully.

(*a*) *Grassy Gully Mine.*—In 1895 the lease was taken up by Moffat. In January, 1900, it passed into the hands of the Grassy Gully Gold-mining Company, with Mr. P. Durkin as mining manager.

The workings consist of three shafts. The principal one was sunk to 185 feet in June, 1900.

At the 170 feet level a drive nineteen feet long was put in to the south.

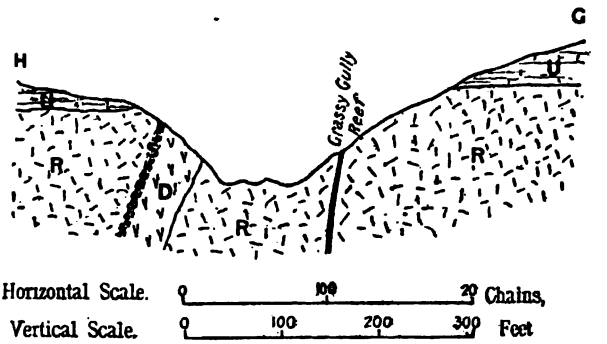
At the 140 feet level a drive twenty-three feet long was also put in to test the country to the south, and at the seventy-eight feet level also a sixty-eight feet long drive was put in (to the south).

These workings are all on the main lode.

No. 2 shaft was sunk on a parallel lode, twenty-five yards to the east of the main lode. This is sixty-six feet in depth. Both "reefs" underlay fifteen feet in every 100 feet to the west. Their strike is almost true north and south.

No. 3 shaft is sixty-seven feet deep. It occurs on the main lode, and has the same underlay as Nos. 1 and 2.

Section on Line H.G. on Map of Grassy Gully Gold-field.



Reference.

U Upper marine sandstone.
D Dolerite.
S Tuffaceous rocks.
R Rhyolite.

Everything sent up from the process of sinking and driving is passed through the battery. The average width worked is from four to five feet. The formation consists of crushed rhyolite, cemented by silica, and a so-called

"reef" of quartz traverses the breccia in places along its line of strike, varying in width from two to twelve inches. Gold occurs in the quartz, and also in joints throughout the crushed igneous rock.

The formation is five feet wide at the bottom of the shaft, and averages 11½ dwt. of gold per ton.

Sixty-five per cent. of the gold in the stone is recovered by the battery and vanners.

The battery consists of ten head of stampers, each weighing six hundredweight.

Punched screens (200 holes to the inch) and copper amalgamating plates are in use. The plant was erected in September 17th, 1900.

A Wilfley vanner is in use. According to Mr. P. Durkin, the capacity of this machine is from fifteen to twenty-four tons per day.

A cyanide plant is to be erected, capable of treating 100 tons per day.

It is expected that eighty-five per cent. of the gold in the tailings will be recovered by cyaniding.

Gold Returns.

Since June, 1898, the following gold yields have been reported:—

Tons treated.	oz. gold.	£	s.	d.
54·5	930¼	3,744	9	2
49·4	344¾	1,395	17	2
77·6	181¼	724	14	1

For the several months prior to 24th November, 1900, 500 tons were also crushed for a yield of 150 oz. free gold, and 4 tons concentrates, averaging 8 oz. per ton. Total, 182 oz.

Total from June, 1898, to November, 1900, 681½ tons, crushed for 1,638 oz. of gold.

(*b*) *Percival's Claim.*—This is almost in line with the main Grassy Gully Reef. It is, however, said to occur on the No. 2 lode, twenty-five yards east of the main lode.

The shaft is about seventy-five feet deep, and the gold is contained both in quartz and felsite.

No gold returns were obtained from this property.

APPENDIX I.

Extracts from W. B. Clarke's "Southern Gold-fields," p. 39–40.

. . . . Yalwal Creek consists of three branches, exclusive of Ettrema Creek. As to the auriferous indications of the Yalwal locality, I can only say, from twelve years intimate knowledge of it, that for several years back I considered it to develop more mineral indications than I had seen elsewhere; and that from my first perusals of the descriptions given of the Turon geology, I felt such a strong conviction of its being auriferous, that during the last six months, I have said to many of the Shoalhaven settlers that, ere long, they should find gold much nearer home than they were aware of, and that as soon as they concluded their harvest I would direct them where to find it; and, accordingly, about three weeks ago, I got a gentleman who had some months' experience at the Turon to accompany me to Yalwal, and who, at one part of the locality said that, had I brought him there blindfolded, he would have declared he was on the Turon ranges. But from all I can learn, I have reason to conclude that most of the Yalwal geology and auriferous indications are more assimilated to those of the Braidwood diggings than any other, as most of its rocks consist of coarse red granite, with a good deal of the "conglomerate" in some parts, and interspersed with ranges of red earth, trap rock, and schist without much quartz, except in one of the creeks, where there are considerable rocks of rather a bastard kind. I have often regretted that Mr. Clarke, in his survey of the Shoalhaven, had not his attention directed to Yalwal. . . . . I have just returned from seeing the prospectors; they have found less or more in every place they tried, except one, and rather more of what I conceive to be platina than gold, but some of which they cast away before I arrived there. . . . .

I have, &c.,

A. K. MACKAY,
Commissioner of Crown Lands.

J. R. Hardy, Esq., C. C. Lands.

Extracts from W. B. Clarke, "Southern Gold-fields," pp. 42, 43, 44, 45, 250.

. . . . In that part of Tasmania, and in the country along Yalwal and the Clyde, Silurian slates bearing auriferous quartz veins undoubtedly occur; and I have also detected abundance of auriferous pyrites, not only in the ferruginous schist, but in the quartzose rocks, and even in the granite of Yalwal, and from the decomposition of these auriferous rocks some gold has been set free in the alluvia. But the mass of the country consists of the rocks of the carboniferous formation, all the members of which may be distinguished, from the lower fossiliferous beds between the coast and Yerrirong Creek and sigillaria shales (in the Danjera Creek gullies). . . . . And, whilst poryphyries underlie the fossiliferous beds below the coal and overlie the gold-bearing rocks, the more recent igneous rocks have broken through the carboniferous formation, transmuted and covered it in various parts of the district, appearing in dykes and in overlying and prismatic masses. . . . . I do not doubt, therefore, that there is some gold to be yet found in the ravines, and all along the broken country between the mouth of the Yalwal Creek and the head of Mongarlow River; but it occurs in iron pyrites mechanically united, and in thin quartz veins, which will require the processes of science for the extraction of the metal. The bearing of these remarks on the general capabilities of the Shoalhaven basin will be seen by reference to the Araluen district. . . . .; but, knowing how necessary is the existence of uncovered auriferous rocks, or if covered, covered only by drift of a certain epoch, I could not, even in 1851, have searched the Yalwal country with any respect for my own opinion of it. . . . . I still incline to think that the drift, and the ferruginous schists and quartzose rocks of the Yalwal Peninsula, will not be found very rich in gold. Not till we have got well up on the table-land of Argyle and Murray, have we reason to conclude that an extensive gold-field can exist. No doubt in my mind remains, that though in Tasmania and in the Yalwal Peninsula the true auriferous slates, with the granites of a more recent date, occur beneath the overlying formations; yet in both regions, alluvial gold can only be expected

in small quantity. Nevertheless, I am of opinion, that between the Sassafras Range and the eastern course of the Shoalhaven, an independent auriferous region does exist, but the value of it can only be determined by long and persevering researches. No sooner, however, do we reach the area of the grey hornblendic or syenitic granites, which are so well developed about Araluen, than gold becomes abundant, diminishing in quantity as we enter the quartziferous schists surrounding it, and becoming very scanty so soon as we come into contact, as in Yalwal Peninsula, with the covering sedimentary deposits of the carboniferous epoch. It has been before stated that the granite of Yalwal is not of that kind; it is rather a coarse pale pinkish rock of loose texture, and having little or no hornblende, with a small amount of mica and bihexahedral crystals of quartz. . . . . It may be mentioned, that on Talwal Creek, which is a Yalwal water, a lode of argentiferous galena was found in 1849, of which an analysis appeared in June of that year. The result gave a very high percentage of silver, but the analyst did not consider it likely to be payable.

Extract from page 250.

In the Yalwal Peninsula, as on Danjera Creek, the same rock† appears associated with Silurian shales and other members of the series, but all of which have been so transmuted by the trappean rocks, as to have become quartzites, or silicified into chalcedony or traversed by thin veins of quartz. This part of the Carboniferous formation has, therefore, undergone the same kind of metamorphosis which distinguishes the lower Palæozoic formation, on which it rests.

† Lower Carboniferous.

DESCRIPTION OF PLATES.

I. Frontispiece. View of Yalwal, looking north.

II. General view of Danjera Creek, looking south from the Pinnacle Claim. Pioneer and Homeward Bound Batteries in middle distance.

III. The Buck Reef. A metamorphosed belt of conglomerate. From the Pinnacle Tunnel.

IV. The Gap. Showing bluffs of upper marine sandstone.

V. Homeward Bound Open Cut. From the Pioneer Open Cut.

VI. Pinnacle and Eclipse Batteries. From the bridge, looking south-west.

VII. Pioneer Battery. From the north.

VIII. Homeward Bound Battery and Cyanide Plant. Looking south-east.

Microphotographs—

IX. Ophitic dolerite.

X. Peculiar Felspar Twinning.

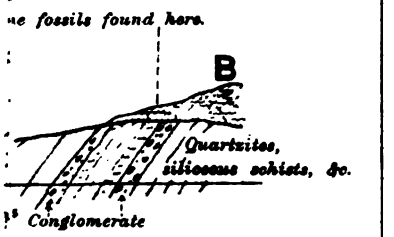
Sydney: William Applegate Gullick, Government Printer.—1901.

PLATE IX.

OPHITIC DOLERITE.

PLATE X.

FELSPAR CRYSTAL IN RHYOLITE.



Spirifers, Productus, &c., in abund

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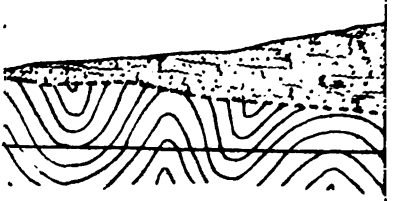
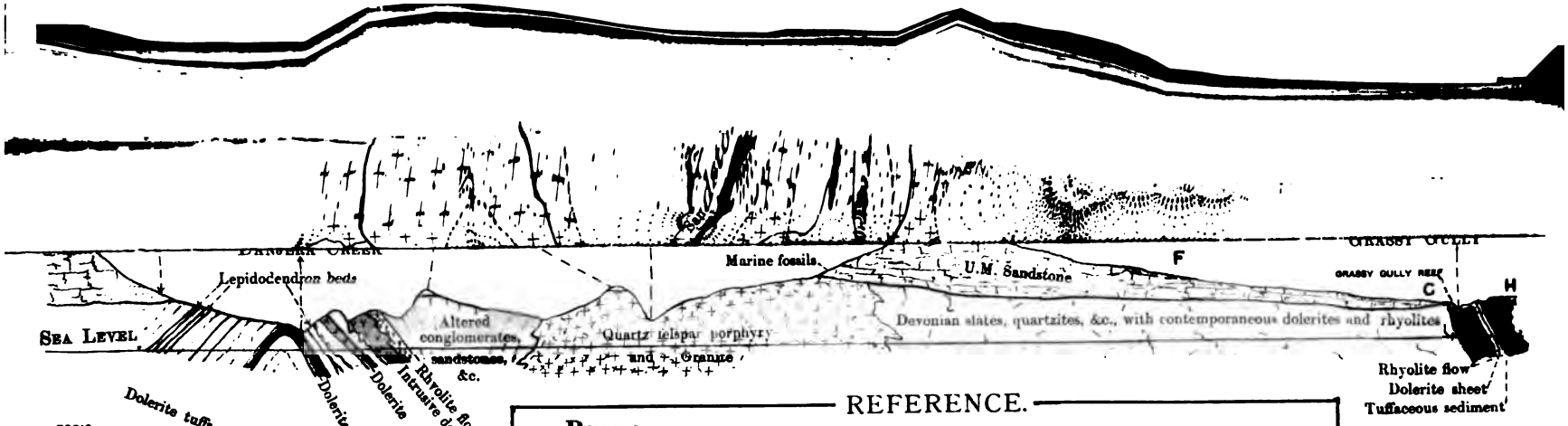




REFERENCE.

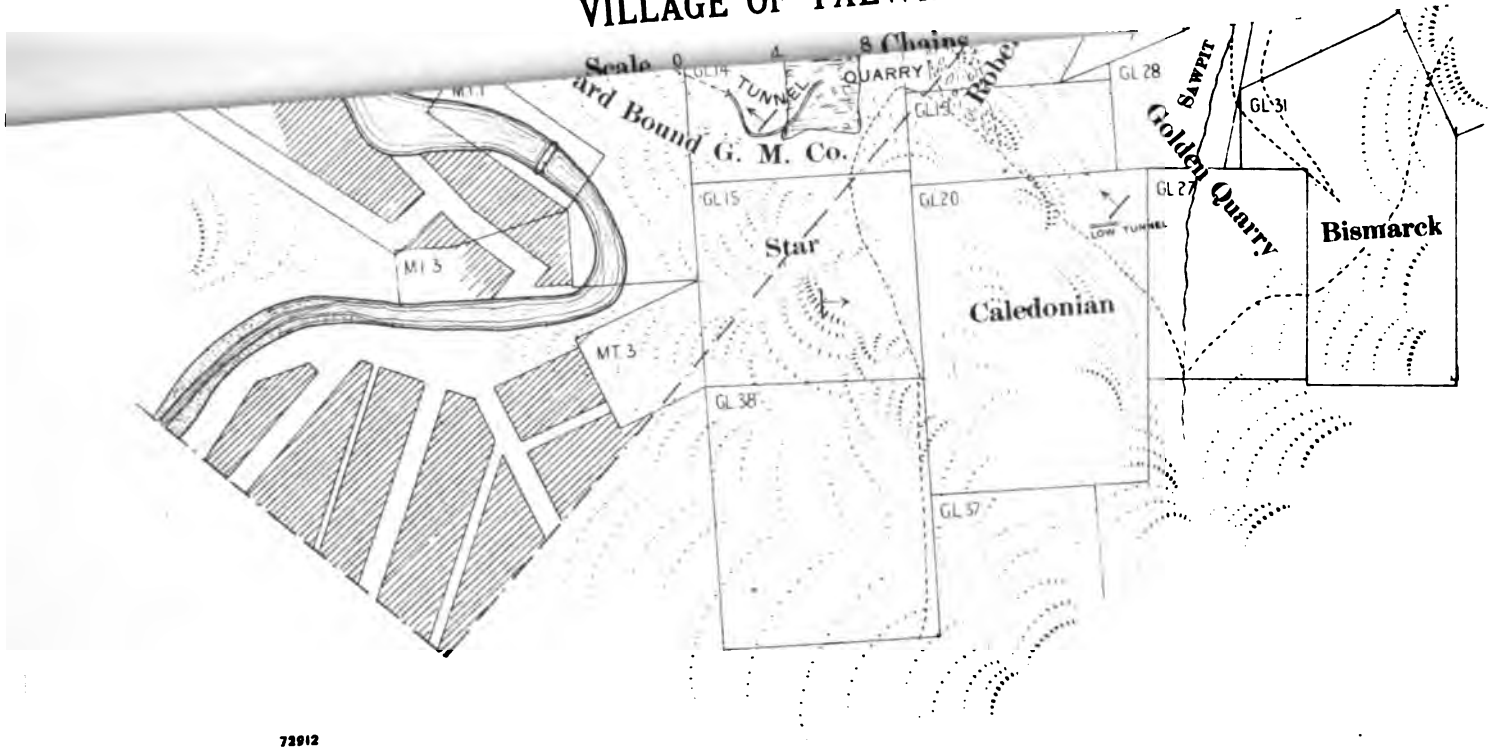
Permo Carboniferous		**Upper Marine** *Sandstones.*
Carboniferous		*Granite, Quartz Felspar Porphyry, Aplite.*
Devonian		*Ophitic dolerites, very vesicular in places, much decomposed, the vesicles being filled with calcite, quartz, &c., and the rock traversed by bands of Serpentine and Epidote.*
Do.		*Banded Rhyolites with tuffs.*
Do.		*Dolerite lavas and sills with sedimentary rocks.*
Do.		*Quartzites, slates, conglomerates, siliceous schists, &c.*

Photo-lithographed by W. A. Gullick, Government Printer, Sydney, N.S.W.

PLAN

Showing Gold Workings, &c., in the

VILLAGE OF YALWAL



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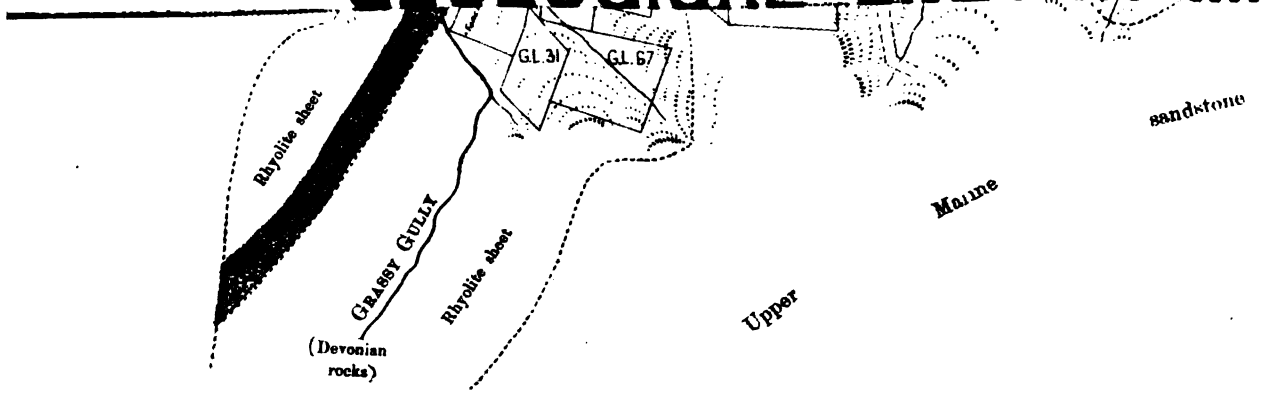
Sydney, N.S.W.

GEOLOGICAL SKETCH MAP



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Sydney, N.S.W.

NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 10.

REPORT

ON THE

KIANDRA LEAD.

BY

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[2s.]

* 81375 A

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Geological Survey of New South Wales,
Department of Mines and Agriculture.
Sydney, 17th July, 1901.

Sir,

I have the honour to submit for publication No. 10 of the Mineral Resources Series, entitled, "Report on the Kiandra Lead," by E. C. Andrews, B.A., Geological Surveyor.

The gold deposits of Kiandra were discovered in 1859, and quickly attracted about 15,000 persons to the locality; but the rich shallow alluvials were soon worked out, and the greater part of the population then departed.

The deep Tertiary lead, from which the shallow gold deposits had been shed, was known to occur in close proximity to the first settlement, and its exposed edges, on the slopes of the hills, received some attention from the pioneer miners, and have been worked in a desultory manner by hydraulic sluicing almost ever since; but it is not practicable to work the central portions of the lead by that process, because of the thick overburden, consisting of beds of lignite and clay, and a capping of basalt, amounting to several hundred feet in the aggregate. Some parts of the deep lead have also been exploited by tunnelling. It is evident, however, that a considerable amount of capital is required to systematically work these deposits, which are of great length and width, have a rather irregular bottom, and are troubled with a considerable quantity of water.

With the object, therefore, of attracting attention to this important but comparatively neglected goldfield, it was thought advisable to have a geological survey of it made, and the course of the lead defined. One of the results of Mr. Andrews' work has been to show that there are two distinct Tertiary river deposits, which he has named respectively the Kiandra Lead and the Round Mountain Lead.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines and Agriculture.

SYNOPSIS OF CONTENTS.

INTRODUCTION.

THE great extent of basalt with underlying drift at Kiandra has long been known to the mining community. Many attempts have been made to prove the auriferous nature of the wash, but they have, for the most part, been conducted in a haphazard fashion.

The following report, with plans, sections, and photographs, has been prepared with the object of showing the extent, probable nature, and auriferous character of the lead.

I desire here to cordially thank Mr. A. R. Winckler for much valuable information and assistance in the field; also Mr. J. M. Lette, Mr. A. Reeckmann, Mr. C. L. V. Jackson, B.E., Mr. Eastwood, Mr. Hetherington, and Mr. C. Burgess, for their kindness in showing me various points of interest in the locality, and in furnishing any information at their disposal concerning the lead.

The maps and sections have been prepared by Mr. O. Trickett, L.S. I desire also to thank Mr. C. E. Murton, Field Assistant, for his cordial co-operation in the work.

REPORT ON THE KIANDRA LEAD.

HISTORY.

KIANDRA (a corruption of the word Giandarra) Gold-field broke out in November, 1859, with the discovery of payable gold in Pollock's Gully by Gillon, Hayes, and Grice.

The first gold had been found, however, in Bullock Head Creek by the Pollock Bros., who were accustomed to bring sheep from the Murray to Kiandra in summer, and, while the flocks were feeding, to spend most of their time in prospecting.

The Pollocks on their return reported the find in Tumberumba. In December, 1859, and January, 1860, a great rush to Kiandra set in.

In February and March it was estimated that 15,000 men were on the field.

The country to the south being exceedingly rough, a surveyor named Ligar devised a route for the Victorian miners by way of the Upper Murray, coming into Kiandra through Happy Jack. This was known as Ligar's Route.

As the diggers swarmed along this and other routes they prospected the area in the neighbourhood of Table Top Mountain and the Four Mile.

Towards the end of January, 1860, the Four Mile rush took place, and about 1,000 miners were soon employed on the spot, many of them making small fortunes.

The Nine Mile also broke out at this time, and kept another 1,000 people employed. The finds here were almost phenomenal.

A week after the Nine Mile rush took place exceedingly rich prospects were found at the Tumut River, on Benjamin's Flat, near the intaking of Scott's Gully and Nine Mile Creek.

The rich properties in the localities just mentioned were almost always confined to small watercourses leading up to the basalt-capped hills, which stretch for a distance of ten miles both north and south of Kiandra.

The following newspaper extracts explain the state of affairs in Kiandra during February, March, and April, 1860:—

"One party consisting of four men got 120 oz. in the week, another party of three were getting 20 oz. per day. Several large nuggets found—6 lb., 12 lb., 14 lb. Another party getting 1 lb. weight gold per diem. The gold procured is coarse and scaly, and large specimens blended with quartz and all much waterworn."—(*Sydney Morning Herald*, 23rd February, 1860.)

"One party before dinner got 176 oz., and another got one lump weighing 19 lb."—(*Sydney Morning Herald*, 25th February, 1860.)

"Five hundred ounces of gold are being got daily. In one dish yesterday they got 21 dwt., and to-day they got 7 lb. weight of gold. One of the party told me they had averaged 20 oz. per day from the beginning. I heard of another party of twelve men getting £73 worth of gold for last week's work."—(*Sydney Morning Herald*, 2nd March, 1860.)

"I saw 80 oz. of gold washed out of one claim in the day's work, and several are turning out 50 oz. per day. These are the best claims from the Surface Hill in the middle of the plains to the edge of the plains where the river begins. The Commissioner has taken with him to Sydney a nugget weighing 48 oz., and another weighing 20 oz., besides a large quantity of coarse gold. The diggers wash out the boxes twice a day. An ordinary yield of gold is from 60 to 70 oz. before dinner and from 30 to 40 oz. at night. Elliot and party of four washed out 80 oz. last week from surface diggings. D. Scully and party have averaged 21 oz. a day for five or six weeks; so have others, some claims have turned out as much as 100 oz. of gold per day, and many as much as 40 and 50."—(*Sydney Morning Herald*, 7th March, 1860.)

"Over an area of half a square mile the workings have proved as rich as any ever discovered in Victoria or California. But, singular to say, beyond this particular spot on the river the precious metal is obtainable only in very small quantities indeed. * * * The Commissioner computes the daily average yield of Kiandra diggings at 500 oz. to a population of 2,500 or 3,000."—(*Sydney Morning Herald*, 20th March, 1860.)

"Many robberies—stickings up. Thieves get their heads close shaved or hair cut. * * * The escort with eleven mounted troopers left Kiandra on Monday with 7,469 oz. It was believed there was fully 5,000 oz. in the hands of the miners, independent of the amount brought down by the escort."—(*Sydney Morning Herald*, 5th April, 1860.)

The field was at first compared with Ballarat and Bendigo, and it was computed that after the winter of 1860 there would be 150,000 men in the locality.

Previously to the rush some exceptionally severe winters had been placed on record, the knowledge of which filled the prospectors with a wholesome dread of the approaching Alpine conditions.

For instance, Dr. Gibson, in the year 1839, had visited the locality, and, struck with the abundance of rich pasture, had erected a stockyard and brought up cattle in the fall of the year. The winter set in, with the usual accompaniment of heavy snow, and all the cattle perished.

A prospecting party on Township Hill had also come on the skeletons of bullocks hanging in the tops of the snow-gums, fully twenty feet from the ground, near the summit of the hill and a considerable distance from any watercourse. It was evident from this that the trees had been covered with snow, to enable the animals to browse off the top twigs.

For these reasons many men kept off the field until the cold weather of 1860 should pass, but the reports were so discouraging at the close of that season that the population did not increase to the extent anticipated. The maximum population was reached about March, when between 10,000 and 15,000 people were on the field. In April, 10,000 were living in the locality. In August, 4,000 were occupied at Kiandra, 200 at the Four Mile, and 400 at the Nine Mile.

The field was patchy, gold being extremely rich in certain spots, barren ground existing within a few yards of the good yields. Surface Hill and Whipstick Gully yielded many large nuggets and specimens, as may be seen by consulting the columns of the *Sydney Morning Herald* for the months of February, March, April, and May of 1860.

One was found by O'Donnell and Party on the east side of Surface Hill Reef, and alongside of the same. This on crushing yielded 28 lb. weight of gold.

On Whipstick Flat another specimen was unearthed by Iles and Party, 27 lb. weight of gold being obtained by crushing.

Many 30 and 40 oz. weight nuggets occurred in the river, and all well rounded.

The gold escort was not established for several months after the start of the field, and most of the precious metal is supposed to have been taken away during the few weeks following on its discovery, and of this no record has been kept. Nevertheless up till 30th June, 1860, the escort had taken charge of 42,000 oz.*

Shortly after the commencement of gold-mining operations at Kiandra it was found that old river drift existed in large quantities under the north and south extension of the basalt. This fact was determined by tracing the gold up the watercourses leading to the basalt cappings of the hills. In this way the Homeward Bound, Cornishmen's, Pattinson and Winckler's, the North and South Bloomfield, and Empress Claims were discovered and opened up.

The Homeward Bound was traced up from Bullock Head Creek by three prospectors, who lighted on an auriferous pothole in the old river channel under the basalt. The gold occurred in a stiff clay matrix. A puddling machine was erected here in March or April, 1860. The prospects from the pothole were good, £1 10s. to £2 a day per man being obtained when water was plentiful. The question of water was at first a great drawback in sluicing. This difficulty was overcome to a great extent in the following December, when the system of constructing races was commenced. The first of these was cut from the Three Mile to the Homeward Bound. With this the pothole was attacked vigorously. It proved to be remarkably rich, 1,000 oz. of gold being obtained.

The Cornishmen's Claim was discovered about April or May, 1860. Half an ounce a day per man was obtained by utilising a little water brought from the top of New Chum Hill.

A miner named "Joe the Frenchman" afterwards procured the claim, and, in the course of a year or two, extracted £800 worth of gold from the base of the drift.

Four Cornishmen then bought the foreigner out. Very good results were obtained by this party.

In the meantime tunnelling had been resorted to in the vicinity of the last two mentioned claims in the hope of thus winning the gold.

The first drive was started under Pattinson and Winckler's sluicing claim by Cameron and Party, who discovered gold in their workings early in 1861.

Colquhoun and Party had another claim alongside, and came on good gold also in 1861.

Drummond and Party drove along the centre of the channel in the same year. From their tunnel the returns are said to have averaged 14 dwt. per superficial fathom. These old workings have since been broken up by hydraulic sluicing in Pattinson and Winckler's Claim.

The Six Mile was worked in the latter end of 1860, £10 a man per week being obtained in the wet season.

At the Empress (Nine Mile) actual sluicing operations commenced in 1860, and were carried on intermittently till 1882.

In 1866 or 1867 the Emperor Company put in a tunnel between the Homeward Bound and Cornishmen's Claims. This helped to establish the width of the channel.

About the end of 1878 these sluicing claims were floated into what was known as the Kiandra Gold-mining Company. In 1882 the Three Mile dam was constructed and connected with the claims by means of a large headrace, 130 feet above the base of the wash.

* Rev. W. B. Clarke. Southern Gold-fields, page 267.

Hydraulic sluicing was started in these claims in 1883.* One nozzle was at first employed, but subsequently an additional one was brought into play.

The Cornishmen's, and Pattinson and Winckler's Claims were afterwards sluiced by hydraulic methods.

In the year 1882 or 1883 the Kiandra G.M. Company introduced hydraulic sluicing at the Nine Mile (Empress) Claim.

A scheme for conveying water to the nozzles from the Doubtful Creek, some 30 miles distant, was considered by Mr. H. B. Sullivan, L.S.,† who took the necessary levels. It was found that two or three large gullies existed across which the water would have to be siphoned.

When the overburden at the Empress Claim reached a thickness of 150 to 160 feet sluicing was abandoned in favour of tunnelling.

At the Four Mile two sluicing claims were taken up, viz., the North and South Bloomfields. Of these, the former was started in 1862, and the latter in 1883 or 1884.

The Giandarra, Robyn's Tunnel, and All Nations' Claims, some two miles to the north of Kiandra, have all been started within the last few years.

The claims just referred to are all on the line of what is known as the Kiandra Lead.

Other sluicing claims have been opened up to the west of the Kiandra Lead; among these may be mentioned the Fifteen Mile Claim, started in 1875 by Hugh O'Connor.

Three miles thence towards the Tumut River and on the Fifteen Mile Creek the sluicing claims known as the Golden Crown and the Phœnix were started in 1883, the former being treated by nozzles.

The Eight Mile Sluicing claim, also belonging to the Fifteen Mile Sluicing Company, was started in 1883.

In all these claims great quantities of drift have been sluiced away from beneath the basalt; but their gold yields were not nearly of so profitable a nature as those derived from the Kiandra Lead.

The Kiandra Reefs.—The finding of the Jackass Flat (1860), Surface Hill (1860), Three Mile (1864), and Charcoal Reefs caused great excitement from time to time. Although the Jackass Flat and Three Mile Reefs paid handsomely at first, they were found to become practically barren at a short distance from the surface.

At present gold-mining operations at Kiandra are confined to the dredging of ground along the Eucumbene River by the Kiandra Gold-dredging Company; to tunnelling at the Empress, Giandarra, and the Six Mile; and to fossicking along Nine Mile Creek, Scott's Gully, Four Mile Creek, the Eucumbene River, Bullock Head Creek, Six Mile Creek, and Racecourse Creek.

The Kiandra bucket dredge (Plate I), working in ground turned over several times already by the diggers, wins from 30 to 35 oz. of gold per week. The revolving screen belonging to this dredge has been taken out, and a sluice-box substituted.

A considerable area has also been taken up along the Tantangara Creek for dredging purposes.

PREVIOUS REFERENCES TO THE KIANDRA LEAD.

C. S. Wilkinson.—Ann. Rept. Dept. Mines for 1880 (1881), pp. 239–242.

H. B. Sullivan.—Rept. on water supply for Kiandra Gold-field. *Ibid.* for 1880 (1881), pp. 265, 266.

W. H. J. Slee.—*Ibid.* for 1885 (1886), pp. 107, 108. *Ibid.*, 1898 (1899), pp. 94, 95.

* Introduced by J. M. Lette, Esq. † Ann. Rept. Dept. Mines for 1880, pp. 265, 266.

KIANDRA BUCKET DREDGE.

L. H. G. Young.—Report on Kiandra Gold-field, and water supply for the same. *Ibid.* for 1880 (1881), pp. 253–258.

W. Anderson.—Report on Kiandra Gold-field. *Ibid.* for 1886 (1887), pp. 165, 166.

J. R. M. Robertson.—Kiandra Gold-mining Company (Limited). Report on Kiandra sluicing claims, New Chum Hill (Fol., Sydney, 1887).

W. C. Roberts.—Report on Victoria Mines, Kiandra. Ann. Rept. Dept. Mines for 1882 (1883), p. 72.

W. D. Bailey.—*Ibid.*, pp. 71, 72.

These two reports sum up concisely all information concerning capacities of dams, lengths of races, &c., employed at Kiandra.

Various Wardens' reports are to be found in the Annual Reports of the Department of Mines, from 1875 (1876) to the present year.

PHYSIOGRAPHY.

Topography.

Kiandra is situated on a high table-land determined as to its general features by the main Snowy Mountain Range, which, disposing itself in pointed-ellipse form in the vicinity of the township, so as to embrace it between its eastern and western curves, passes through to the south by way of Table Top Mountain. (Pl. II.)

The town is some 4,600 feet above sea-level, and lies 58 miles south-east of Tumut, 51 miles west-north-west of Cooma, and 40 miles north of Kosciusko.

The table-land is dotted over with numerous hills composed of tuffs, slate and granite, rising to heights of 1,000 to 2,000 feet above the general level. Among these peaks may be mentioned the Big Bogong (6,753 feet), Table Top Mountain (5,850 feet), the Round Mountain, Alpine Hill, Governor's Hill (5,723 feet), Yarrangobilly Peaks, and Peppercorn.

The main range, in the vicinity of the town, is typically flat-topped, a feature due to its basaltic capping. Through Governor's Hill (Kiandra Trigonometrical Station) the range sweeps round to the north-west by way of the Six Mile (where the basalt starts), Gooandra Trigonometrical Station, and Bullock Hill (Pl. II); thence, turning sharply on itself, it passes through the Three Mile, leaving the town to the immediate east; through Township Hill, Nine Mile, Table Top Mountain (where the basalt ceases), the Bull's Peak, and Mt. Kosciusko.

On each side of the plateau profound gorges occur, expressions of the amount of material removed by such streams as the Tumut during the process of excavating their present channels.

The Snowy Range forms the watershed for the local streams. The chief water systems are those of the Snowy and Murrumbidgee Rivers.

Inside the sharp curve formed by the main range at Bullock Hill the Eucumbene gathers together its head waters, and flowing towards the south joins the parent stream (the Snowy River) at Jinderboin.

The Murrumbidgee River has, as its chief feeders in this district, the Tumut and the Goodradigbee.

The main stream rises in a mountain known as Peppercorn. Here also the Goodradighee has its source, flowing many miles before uniting with the trunk stream.

The Tumut takes its rise in the neighbourhood of the Big Bogong and the Bull's Peak, and carves its way through the mountain blocks to the Murrumbidgee in a perfect labyrinth of gorges, some as much as 3,600 feet below the general level of the plateau.

Besides the basalt mass which forms the summit of the Snowy Range in the neighbourhood of Kiandra another and larger one apparently has its source, or one of them, in the vicinity of the Round Mountain. From this as a centre it flows in the direction of the Tumut River, through the Fifteen-mile and Eight-mile claims, then across the Tumut by way of New Meragle, and thence in the direction of Batlow.

These basalt flows are further interesting by reason of the comparisons which may be instituted by a study of them between present and late tertiary topographical conditions.

(1.) From the Nine Mile to the Twelve Mile, a distance of 20 miles, the Kiandra lead shows a fall of 785 feet.

This then indicates the direction of the old stream, viz., from south to north.

The present Encumbene River rises near the Six Mile, and flows thence past the Nine Mile. Thus the two streams ran in opposite directions.

The Round Mountain lead has a fall in the direction of the Fifteen Mile, Eight Mile, and New Meragle. Its course is thus fairly parallel for miles with that of the present Tumut River.

(2.) The basalt flowed along the old river-beds, thus occupying the lowest portions of the country at that period.

(3.) The Tumut has cut very deep ravines through these basalt caps and the underlying rocks.

Near the Fifteen Mile Claim the Tumut gorge is 2,500 feet deep; the basalt has been trenched across, and occupies at present the highest portion of the land in the neighbourhood.

At New Meragle wash with basaltic covering has been found near the edge of the Tumut gorge and 2,200 feet above the stream, while the Tumut River at its junction with the Yarrangobilly is 3,600 feet below the basalt cap forming its eastern bank.

From (2.) and (3.) we see how potent have been the forces of erosion since the basalt outburst; for since the deep leads represent the lowest levels reached in Tertiary times, and seeing that the basalt occupied these lowest sites, and also that the present rivers have cut their way through the basalt cappings, it is clear that all gorges in the locality below these old levels must post date the period of basaltic eruption.

(4.) The leads show a great quantity of alluvial deposits, amounting to a thickness of 150 feet and a width exceeding 10 chains, while the present river beds of the locality are small and rapid with scanty deposits of wash.

In the neighbourhood of the Nine Mile even to day the leads are separated by a ridge of rock much more elevated even than the Nine Mile claim. Taking into consideration the enormous amount of denudation effected since the existence of the leads as water systems, the great quantities of gravel and lignite contained in the leads themselves, it is only natural to surmise that a little while before the basaltic outbursts two large streams flowed in the neighbourhood of Kiandra, one in a northerly, the other in a north-westerly direction; that they were separated in the vicinity of Kiandra and the Nine Mile by a high ridge; that they have their sources in the mountains to the south, which were much more conspicuous than at present, besides being perenially snow-capped during a certain period, and that at various stages of the river history the vegetation along the banks formed growths comparable in luxuriance with those seen in the "brushes" of the present coastal areas.

Meteorology.

Kiandra district has no well-defined seasons. The summer weather is generally mild and pleasant, but heavy frosts and snowstorms have been recorded in December and January. One storm is mentioned during which

KIANDRA TOWNSHIP AND EUCUMBENE RIVER.

3 feet of snow fell on the 26th December. The average annual temperature is 44·5 degrees, the maximum officially recorded shade temperature is 85°, and the minimum—20° (52 degrees of frost) in August, 1882.

The rainfall is 63·78 inches per annum, and the town, in severe winters, is almost buried beneath snowdrifts.

The prevailing wind is from the north-west.

Vegetation.

The mountain ash attains a prodigious height in the deep gullies. At the bases of these gorges messmate and white gum abound.

The hardy snowgum is the only timber that can withstand the wind and snow in exposed situations at altitudes exceeding 5,000 feet. On the windward sides of the hills these trees have a regular network of branches, twisted into all manners of curves, and possessed of exceeding toughness so as to withstand the great snow pressures they are subjected to. In these shelterless spots also the snow timber permanently leans to the south-east, owing to the force of the prevalent north-west wind.

At altitudes exceeding 6,000 feet no trees will grow.

Heaths, peaty growths, and stunted vegetation are exceedingly common. On the gathering grounds of the streams a curious phenomenon occurs, the surface over large areas appearing as if stripped in places for turf-getting. These bare patches are always narrow as compared with their length, being bluntly crescentic in shape. A frequent width is 2 feet with a length of 10 feet. They occur as depressions, some 6 to 8 inches in depth, and are almost equal in total area to their well-grassed surroundings. They are always arranged normally to the direction of flow of the water, and occur only on spots with little or no fall. The ground around is remarkably well grassed, being quite springy when walked upon.

They form a most instructive lesson in the compromises effected between animate and inanimate forces in the adjustments of their respective boundaries.

At the points on the hillsides where the water issues from beneath the basalt capping thick spongy masses of vegetation collect, sometimes as much as 3 and 4 feet in thickness.

GEOLOGY.

1. General Geology of District.

The geological formations in the vicinity of Kiandra are extremely interesting, consisting as they do of well-marked claystones, breccias, conglomerates, sandstones, quartzites, shales, fossiliferous limestones, hard siliceous and soft fissile slates, tuffs, and felsites (?) intruded by sills of syenitic-diorite, norite bosses, basic andesites, quartz-felspar porphyries, gneisses, and granites.

Of the rocks observed, the oldest occur in the neighbourhood of Lobb'sHole Copper-mines, and consist of siliceous claystones, breccias, conglomerates, sandstones, and quartzites. These, the lowest members of the series, are in the main suggestive of very shallow marine conditions. The finer-grained sandstones and the quartzites further emphasise this point by reason of well-preserved ripple marks and annelid (?) tracks found in them.

The upper 100 feet of these rocks, by reason of superior hardness, outcrop boldly on the hillsides (Plate III), sweeping up or down the ravine slopes according to the prevailing dip. These constitute such a marked feature in the landscape as to be known as "The Walls."

Above these large lenticular patches of limestone were laid down, containing abundant fossil remains.

To these succeeded great masses of shales and slates, indicative of deeper sea conditions.

These in turn gave place to great accumulations of fine and coarse tuffs of an andesitic character. Rocks here occur possessing markings similar to the flow-contortion structure seen in many felsites, as well as small bands of tuffaceous slates.

Slates and sandstones, since silicified in great measure to quartzites, mark a still later period of sedimentation.

The younger members of the series, *e.g.*, the tuffs, quartzites, and slates, appear to have been intruded by rocks showing affinities with both quartz-syenites and quartz-diorites in the form of a large sill with smaller attendant dykes.

In Racecourse Creek another type of rock, possibly also a syenite, occurs in the form of bosses and sills. This, as also the syenitic-diorite, appears to have partaken in all the dynamic metamorphism of the district.

Several basic andesite dykes occur in the neighbourhood of the dioritic rock, and are doubtless associated with it. These rocks are also extremely altered.

Small norite bosses appear to have made their appearance next.

Equally small granite bosses occur, which weather out into very similar forms. Both are scattered capriciously over the field, and appear to be closely associated with each other, and probably do not differ much in age.

In Carboniferous (?) times the great districtal disturbance took place in the form of huge granitic and gneissic intrusions. This is the age of so much of the granite and granitite of Eastern Australia.

Most probably the whole of the Upper Silurian strata of the district was influenced by earth movements, and became possessed of a fairly high angle of dip at a period ante-dating the granitic intrusions. These latter, however, were on a magnificent scale, and there is little doubt that in the Kiandra district the crumpling of the rocks observable along the Yarrangobilly River was determined mostly under the influences of these acid bosses.

After the close of the Palæozoic period geological influences were mostly confined to the work of disintegration and erosion. The mountains were planed down, the granite massifs which had cooled at great depths were bared, and themselves fashioned into high peaks.

In middle and late Tertiary times the rivers of the district were larger and flowed in the opposite direction to the present course of the Eucumbene River.

A long period appears to have been occupied in the formation of huge deposits of river material. Subsequently different climatic conditions obtained. Luxuriant growths of vegetation, attended doubtless by much milder temperatures and abundant rainfalls, clothed the banks of the ancient rivers. These formed the thick masses of carbonaceous material which form such a prominent feature of the "lead" sections.

After the deposition of the lignite, sand, clay, and fine river-wash were deposited in thin beds, to be followed by other beds of lignite.

After several alternations of stony and carbonaceous layers, a great basaltic outburst took place, probably in late Tertiary times. From different centres, such as Table Top Mountain, Round Mountain, Pig Gully Hill, &c., basalt was poured out in great streams, filling up the old river-beds for many miles. The diverting of the streams into other channels by this volcanic display has been discussed under the head of physiography, as also the probable amount of material removed by atmospheric agencies since that time.

"THE WALLS," LOBB'S HOLE.

2. Sedimentary Rocks.

(*a.*) *Recent and Pleistocene—Shallow alluvial deposits—Calcareous deposits in watercourses.*

To those belong the present shallow "placers" of the district, and the masses of travertine encrusting the strata underlying the bedded limestone at Lobb's Hole.

At this locality a large mass of limestone occurs, immediately overlying the hard quartzite formation known as "The Walls." These occur as almost sheer faces, varying in height from 40 to 250 feet. Near the Copper Mines masses of travertine encrust "The Walls" at the heads of the gullies, and have in one or two cases the appearance of limestone inliers. Their origin is instructive. On the top of "The Walls" a species of tea-tree scrub flourishes in the soft tufa brought down the watercourses. Alongside of these also thick masses of mossy growths flourish in the tufa. The calcareous material is deposited on these vegetable growths, and quickly covers them up, but the lowly vegetation grows upward and outward, so that as the lower portions are wholly enclosed by the tufa the upper part is still vigorous. Thus the secondary calcareous material has a tendency to advance in an upward and outward direction. The tea-tree masses also flourish on the perpendicular face of the tufa, and are being continually buried in the calcareous mass. The tufa thus formed is extremely light and porous, but as the mass thickens the vegetable constituent perishes, and percolating waters consolidate the whole into compact limestone and calcite. In one place this secondary growth has advanced fully 70 to 100 feet in front of the quartzite precipice, and is itself a precipice fully 100 feet high and 200 feet in width. The old part in contact with the base is of calcite, eaten into large caverns containing many beautiful stalactitic growths, while the perpendicular face of the travertine or tufa is covered with tea-tree and mossy mass. All the tea-tree branches and roots have a thick coating of tufa.

(*b.*) *Tertiary.*

The Kiandra Lead—The Round Mountain Lead.

The Kiandra Lead.—The deposits occurring in this lead consist of the following, with local modifications:—

1. Auriferous wash.
2. Sand and clay.
3. Iron pyrites.
4. Earthy lignite.
5. Clay and sand.
6. Earthy lignite.
7. Sand and clay.
8. Earthy lignite.

The total thickness of the beds is about 150 feet. Abundant traces of leaves are contained in the layers of lignite. Perfect specimens are rarely procured, owing to the softness of the matrix.

The Round Mountain Lead.—The succession of beds here has been discussed elsewhere in the report, as also the occurrence of leaves in an excellent state of preservation.

C.—*Upper Silurian* (?).

The strata of this Palæozoic age fall naturally into five divisions:—

(1.) A lower series, consisting of claystones, breccias, conglomerates, sandstones, and quartzites, the upper beds of which form "The Walls." (Plate III.)

Of these, the breccias and conglomerates deserve special mention. They are lenticular in character, attaining enormous local developments. At the Copper-mines the breccia forms a thin sheet, containing angular fragments of quartzite about the size of a walnut. A mile to the east it makes into a much thicker bed, the dip of which corresponds with that of the mountain it constitutes in part. The quartzite fragments are large, varying from 6 to 18 inches in diameter, and are set in an impure quartzite cement. This cement weathers more rapidly than the enclosed fragments, and the weathered surface of the breccia then has the appearance of a rough talus slope. The fragments, however, when struck with a hammer, are found to be *in situ*.

The conglomerates and grits are closely connected with the breccias, and form in the Yarrangobilly River cañon cliffs as much as 100 feet in height. The bulk of the strata is composed of well-rounded quartz pebbles, set in an insignificant amount of cementing sandstone. The pebbles vary in diameter from 1 to 12 inches. They rest on fissile slates and quartzites.

The overlying sandstones are indurated, and the quartzites very fine in texture.

(2.) *The limestones* are lenticular in character. Two deposits occur, one at Yarrangobilly, the other at Lobb's Hole. Their periods of deposition are probably not far removed, although the folding to which the country has been subjected would necessitate detailed examination to decide this point. The principal difficulty lies in the great variations in the dips, and the very local development of rock characteristics, conglomerates giving place to sandstones and slates within very short distances.

The following fossils, obtained from the Lobb's Hole limestone, have been identified by Mr. W. S. Dun, Palæontologist to the Survey:—

Spirifera Yassensis. *De Koninck* (abundant).
„ multiplicatus. „
Pentamerus Knightii. *Sowerby*.
Rhynchonella (Uncinulus) Wilsoni. *Sowerby*.
Chonetes striatella. *Dalman*.
Athyris, or Meristella.
Modiomorpha (?).
Fragment of a rugose coral, Amplexus (?).
Orthoceras.

Mr. Etheridge has also determined from these beds—

Spirifera latisinuatus. *De Kon*.
Rhynchonella cuboides. *Sowerby*.

The latter most probably is the form listed above as *R. Wilsoni*.

A species of *Paracyclas* has also been collected from these beds by Mr. Warden Love.

At Yarrangobilly the predominant brachiopod is *Pentamerus Knightii*, represented at Lobb's Hole by a single fragment.

Associated with *Pentamerus Knightii* in these beds are found (as determined by Mr. Etheridge in 1894)—

Bellerophon (two species).
Euomphalus, or Oriostoma.
Ptycomphalina.
Cyclonema.
Murchisonia (Hormotoma, or Cœlocaulus).
Pleurotomaria (Mourlonia, or Ptycomphalina).
Orthodesma (?), and a large indeterminable bivalve.

(3.) The slates have a higher and more uniform dip than the lower conglomerates and breccias. They are very fissile, "creeping" structure is of common occurrence; decomposition has set in, turning the slates to a green colour, and silicification is very pronounced.

Most of the reefs occur in these strata. The prevailing strike is N. 15° E.

(4.) *The Tuffs.*—These form the majority of the rocks about Kiandra township. They occur as bands of coarse green rocks alternating with fine-grained grey varieties having a felsitic appearance. Although conforming in the main to the strike of the country, they present decided local variations, the strike of the beds in these cases being at times at right angles to the prevailing trend of the country. The tuffs at times are so compact as to be almost indistinguishable from igneous rocks. They have been classed hitherto as diorites. In the finer-grained varieties the fissile structure so pronounced in slates are characteristically absent.

(5.) The quartzites and siliceous slates to the east of the tuffs possess the same general strike as the fissile slates to the west. They are extensively developed about Sawyer's and Governor's Hills. No traces of fossils have been discovered.

C.—*Eruptive Rocks.*

1. *The Syenitic-diorites.*—These occur mostly in the form of a huge dyke or sill, more than 6 miles in length, and conforming generally to the strike of the associated slates and tuffs. The map shows its approximate boundaries only. In several places it is reduced to two or three narrow dykes, while at the Eucumbene River and at the Four-mile Creek it broadens considerably. Its probable north and south extensions beyond the limits shown on the accompanying map were not followed.

The rock weathers out into ragged forms, and not after the typical manner of coarsely-grained plutonic rocks. Its age appears to considerably ante-date all other intrusive igneous rocks of the locality. The component minerals have been much decomposed; the forces of dynamic metamorphism are very evident, and slickensided epidote is a common constituent.

Numerous syenitic dykes attend the main line, especially on Sawyer's Hill, near the intersection of the Cooma-Kiandra road with the Eucumbene River.

Several very basic andesitic dykes appear to be associated with this syenitic rock. They are composed of uralitised augite phenocrysts set in a fine matrix. They appear to have been much altered.

2. *The Norites.*—These occur as very small rounded bosses, weathering out into large spheroidal blocks, after the manner of coarse varieties of plutonic rocks. The largest exposure occurs at Kiandra township itself, and is from 15 to 20 acres in extent. A few blocks occur at the head of Whipstick Gully. A small patch near Charcoal Reef is associated with a small biotite granite boss. An outcrop, about 1½ acres in extent, occurs at the Eucumbene River below the basalt claim; and another in the Four-mile Creek.

At Kiandra the rock is basic, and exceedingly tough in character, by reason of the great amount of contained hypersthene.

Curious structures are noticeable in the mass, thin layers of varying basicity occurring in some of the blocks, giving the appearance somewhat of stratification.

The occurrence of small bosses scattered capriciously over the field points probably to the existence of a much more extensive mass below. The dykes associated with these bosses also weather out in spheroidal blocks.

These rocks do not appear to have suffered nearly so much from the agencies of metaphorphism as the older syenitic rocks.

Gneisses and Granites.—The acid plutonic rocks of the district probably belong to the Carboniferous Period.

At New Meragle biotite granite possesses a decidedly banded structure. This rock has a fresh appearance.

At Rocky Plain, Governor's Hill, Alpine Hill, and Table Top Mountain a ternary granite occurs. The constituent minerals do not appear to have suffered much from metamorphic influences.

These acid rocks have a very extensive development, and their intrusions appear to have caused the pronounced crumpling in the local strata.

In the tuffs and slates very small granite bosses occur, one behind the Cemetery Reserve, one at Pig Gully, and one at Charcoal Reef, closely associated with a norite boss.

Quartz-felspar porphyries.—Irregular masses and dykes of acid porphyry occur in the district, and may be connected with the granite of Rocky Plain, although they have not been traced into any boss. They are decidedly younger than most of the igneous rocks of the locality, cutting across the line of strike of the syenitic rocks and the basic-andesitic dykes.

The Basalts.—These are of basic types, containing abundant olivine crystals. They occur as extensive sheets overlying Tertiary river deposits.

Several local eminences, having the shape of truncated cones, and composed in their upper portions of basalt, have suggested the probability of their being volcanic foci at one time. These points are known as Table Top Mountain, Round Mountain, and Selwyn Trigonometrical Station.

Table Top Mountain is 5,850 feet above sea-level, and is composed of tuffs (Silurian), slates, quartzites, and granites, having a thin capping of basalt, about 200 feet in thickness. The basalt on the eminence is at present isolated, and at its base between 200 and 300 feet above the Nine-mile Lead. Numerous inclusions of plutonic rocks, allied to syenites, occur in the basalt. A careful search was made for signs of volcanic eruption, such as tuffs or scoriæ; none were found. Mr. L. H. G. Young, formerly Geological Surveyor in the Department of Mines, mentions the occurrence of a solitary fragment of volcanic breccia* on the hill summit. It is very probable that this elevation formed one of a group of centres from which basalt was poured forth over the "leads."

Selwyn Trigonometrical Station is of similar formation to Table Top, consisting of Palæozoic tuffaceous rocks with a very thin capping of heavy olivine basalt. The basalt of the hill and in its near neighbourhood exerts a decided influence on the compass. Thus on one side of the trigonometrical station the deflection was 15 degrees; on another side it amounted to 35 degrees; while 1,000 yards away, on basalt of similar appearance, the deflection was as much as 65 degrees.

THE LEADS (1).

These are two in number, and may be called "The Kiandra Lead" and "The Round Mountain Lead." In both instances they lie beneath wide basalt flows, and the record of them is preserved only as the basaltic cap resisted the encroachments of the weather. The basalt itself, in the first instance, was determined in its main features by the course of the old rivers now constituting the channels of the present leads. The streams being diverted from their courses, cut for themselves other and lower channels, and have since been attacking the basalt mass. This from its superior hardness has resisted the various attacks made on it, while deep cañons

* Ann. Rept. Dept. Mines for 1880, p. 254.

Section of Working Face . New Chum Hill

PATTINSON AND WRICKLER'S CLAIM

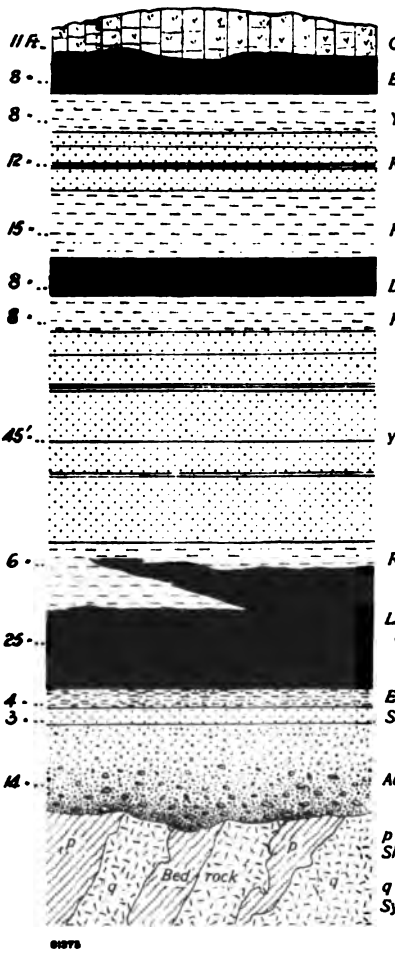


Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

have been carved out in the softer contiguous strata. But even the dense basalt has yielded in great measure to the stress laid upon it, partly by the action of severe frosts, and partly by percolating and eroding waters, until, as will be seen by glancing at the accompanying map, at least one-half of it has vanished, superficially considered.

When the basalt covering in part was removed, the soft underlying alluvium was quickly washed away.

The gold contained in the old channel would, however, remain for a still greater length of time, and while the wash itself disappeared, much of the gold would remain in more modern and neighbouring watercourses, although at lower levels than the parent channel.

Both of the deep leads have been proved over great distances.

The Kiandra Lead.

1. *Extent.*

Near Table Top Mountain the Kiandra lead has been proved by the excavations known as the Empress sluicing claim.

Here beds of lignite, clay, sand, and wash exist, having a total thickness of 160 feet. (*See* Diagram .)

From 10 to 15 chains beyond the "Empress" to the north a series of shallow shafts have been sunk in river drift similar to that occurring in the upper portions of the Empress.

Two miles to the north of the Empress, and under the same line of basalt, the South Bloomfield sluicing claim exposes another section of the old drift. Thence northwards the basalt has been worn away for a distance of nearly 2 miles.

At the point where the basalt makes again abundant evidence of the lead is present on the hill slope under the lava sheet in the form of wash, clay, and lignite, similar to that shown in the Empress and South Bloomfield claims.

Following the line of basalt known as Township Hill, various signs of the lead are apparent as one nears the northern portion of the hill.

In Pollock's Gully a shaft has been sunk through lignite and clay; two tunnels at the northern point of the hill have been driven through lignite and wash.

Lignite occurs also on the north-west portion of the hill, and close to the south-west corner of G.L. 60 a shaft 75 feet deep has been sunk through lignite and wash.

At the northern extremity of the hill, Bullock Head Creek has cut through the basalt, which latter is met with again on the southern portion of New Chum Hill.

Here for 40 chains along the southern boundary of the hill the various hydraulic sluicing claims known as Pattinson and Winckler's, the Cornishmen's, and Homeward Bound Claims demonstrate the presence of abundant drift underlying the basalt cap. (Frontispiece.)

Northerly, further evidence of the lead is present on the hillsides near the Giandarra, Luttrell's, and All Nations Claims. These also, consisting of tunnels and open cuts, have all proved the presence of wash and lignite similar to that obtained in the various sluicing claims already enumerated.

At this point a gap occurs in the basalt line, due to the erosive action of the Six Mile and Racecourse Creeks, the lava reappearing to the north at the Six Mile workings.

Similar wash to that found at New Chum and Township Hills is here exposed on the hillside beneath the basalt.

On the main Tumut Road river sand is exposed on the roadside at the 50½-mile post, and underlying the basalt.

Further north again, at the Twelve Mile, and at a point where the Murrumbidgee River has cut across the basalt, Luttrell's tunnels have proved the existence of well-rounded wash beneath the basalt.

Wash has also been reported beneath the basalt from various places north and south of the above limits, *e.g.*, at a spot several miles to the south of Table Top Mountain and a locality some 20 miles north of the Twelve Mile.

2. *Argument in favour of lead instead of lake formation.*

The existence of a lead at Kiandra has been denied by many. The contention is that similar wash occurs at the Fifteen Mile, the slopes of the Tumut River, the Eight Mile, New Meragle, and other places; that the latter are altogether off the line of the supposed Kiandra Lead; and that the evidence is rather in favour of a large lake formerly stretching across Monaro, and embracing the country from Happy Jack, Tumberumba, and Broken Cart.

If a lake, the bed should not be altogether confined throughout its length between narrow walls; and the drift should not be of an even thickness throughout, but should form overlapping masses of water-worn material thicker in places than others.

On the other hand, if the wash can be shown to be confined to a long narrow channel, the levels of the bed-rock under the wash to be possessed of a continuous rise or fall as one passes the various claims in any given direction of length, and the wash to be evenly distributed along its length, then the evidence in favour of an old river-bed is undeniable.

(*a*) Evidence derived from study of the old channel banks.

At the Empress Claim (Nine Mile) bed-rock occurs to the north-west, rising above the base of the wash to a height of 50 feet. Ten or fifteen chains to the north the older rock is 150 feet higher than the lowest portion of the drift, and shuts the old channel off to the east under the basalt.

To the east again, and at a distance of some 40 or 50 chains, the bed-rock may be traced for a considerable distance beneath the basalt, and rising high above the level of the wash.

In the immediate vicinity of Table Top Mountain the wash has been removed by atmospheric agencies; but here, also, it was extremely narrow, for the high ridge of rocks forming the main Snowy Range confines it to the east, while to the immediate west the country rock is considerably higher than the old channel level.

At the South Bloomfield the wash is surrounded on three sides by high ridges of rhyolites and tuffs, the old channel being open towards the basalt only on the south-west.

At the North Bloomfield the original channel is well exposed; but, to the west, there is no sign of it, the place being occupied by rhyolite tuffs and slates much higher than the wash level. These tuffs and slates may be traced beneath the basalt on the west side of Township Hill, signs of the old channel becoming abundant only near the northern point of the hill at G.L. 60.

Similarly the channel is enclosed to the east of the same hill, the bed-rock outcropping beneath the basalt at heights considerably above the base of the wash. At Basalt Claim signs of wash are frequent. Here it is again confined (*see* Diagram), and from a consideration of the distribution of the basalt probably belongs to a tributary of the main stream.

Behind the Cemetery Reserve, in Commissioner's Gully, and on a large spur enclosing Pollock's Gully to the south, the enclosing of the old channel is specially well marked.

The spur just mentioned, composed of felsites and tuffs, rises some 300 feet above the wash, and stretches for over half a mile into the valley below, forming a huge buttress to the basalt-capped hill.

Immediately behind this shoulder of bed-rock, lignite and clay crop out in Pollock's Gully. As these are, however, 150 feet above the base of the wash in Township Hill Tunnel, 50 chains away, they probably represent the upper layers of the made ground. Here, also, immediately to the east of the shaft, the bed-rock outcrops some 120 or 130 feet above the wash level.

Thence to Township Hill Tunnel the bed-rock is from 70 to 100 feet above the auriferous wash, with, possibly, a slight outletting of the channel in the vicinity of Wesselman's Tunnel.

At the north-east corner of Township Hill the channel appears to be exposed in a natural section. Here pebbles, sandy wash, clay, and lignite over 100 feet in thickness outcrop on the hillside. (Plate VI.)

Across Bullock Head Creek the wash is well exposed on the southern end of New Chum Hill. By sluicing and tunnelling the channel has here been proved to have (over a distance of 40 chains) a narrow course rarely exceeding 10 chains in width, and confined on both sides by banks of tuffs and tuffaceous slates, and to have a westerly course.

Thence towards the northern point of New Chum Hill the channel appears almost totally confined beneath the basalt capping of the hill.

In Garden Gully, on its southern side, the bed-rock rises 100 feet and over above the level of the wash in the various claims just named. On the north side of the gully the basalt talus is excessively thick, concealing all traces of the underlying rocks.

A high spur of slates encloses Garden Gully to the north-east, shutting the channel off on the east. Immediately to the north of the spur signs of wash are abundant on the hillside beneath the basalt.

Here also the Giandarra and Robyn's Tunnels, Luttrell's and All Nations' Claims have proved the channel over a considerable distance, though they have not settled beyond doubt the width of the wash.

Near the All Nations' Claim the channel has been cut across by later streams.

Some 10 chains to the west the bed-rock (an igneous variety) rises 100 feet above the wash, and forms the western channel bank.

Thence for several miles to the west and south, following the basalt along New Chum Hill, the bed-rock can be traced at a much higher level than the wash.

At Reid's Gap the slates are 150 feet higher than the channel bed.

From All Nations' Claim to the north both basalt and wash have been removed by the forces of erosion over a distance exceeding 2 miles.

At the Six Mile workings the basalt is picked up again, and with it the auriferous wash, its cappings of lignite, clay, and sand. Here, again, as at New Chum Township and Nine Mile Hills, the channel is confined between high eastern and western banks of rock for miles, by way of Gooandra Trigonometrical Station.

On the main Kiandra-Tumut road, 10 chains north of the 50-mile peg, much sandy river material is exposed beneath the basalt in the road cuttings, and enclosed on both sides by slaty rocks.

At Lander's old tunnel, about a mile west of Tantangara Creek, the wash has again been proved, though its exact width has not been ascertained;

also in two other tunnels driven by the same person, one about 10 chains from the Murrumbidgee River, the other at a spot where the Murrumbidgee has cut through the basalt cap.

The various points just enumerated, at which the old channel has been confined within narrow banks, are all indicated on the accompanying map.

(*b*) Evidence from character of the wash.

Wherever exposed, as at the Six Mile, New Chum, Township, and Nine Mile Hills, the drift has a fairly uniform character and thickness (*see* sketch sections across the various claims).

More or less auriferous wash is always overlain by layers of earthy lignite, clay (with thin bands of ironstone at the Four Mile and Nine Mile Claims), and sand layers, and the amount of made ground is almost without exception from 150 to 170 feet in thickness.

(*c*) The evidence of the levels.

Levels were run with a dumpy from the Six Mile to the Bloomfields. The heights of outlying points, such as the Nine Mile and Twelve Mile workings, were ascertained by means of an aneroid.

Starting with the lowest wash observed in the Old Six Mile workings as a bench-mark, and passing each claim in succession southwards to the North Bloomfield, the levels obtained are as follows:—

	Feet.
1. Six Mile workings (lowest portion of wash seen)	0·000
2. Giandarra Tunnel mouth (nearly on same level as wash) ...	9·770
3. Pattinson & Winckler's Sluicing Claim (base of wash) ...	31·980
4. Homeward Bound Claim (base of wash)	32·548
5. Township Hill Tunnel mouth (approx. same level as wash)	58·085
6. North Bloomfield (base of exposed wash)	309·525

Combining aneroid and dumpy level readings, commencing with the wash at the Twelve-Mile as a base, we have the following:—

	Feet.
1. Twelve Mile (Lander's claim)	0·000
2. Six Mile workings	226·915
3. Giandarra Tunnel mouth	236·685
4. Pattinson & Winckler's Claim	258·895
5. Homeward Bound Claim	259·463
6. Township Hill Tunnel mouth	285·000
7. North Bloomfield	536·440
8. South Bloomfield	641·440
9. Empress Claim (Nine Mile)	785·000

There is thus a fall of 785 feet from the Empress Claim to the spot where the Murrumbidgee River cuts through the basalt at the Twelve Mile, a distance, measured along the road, of 20 miles.

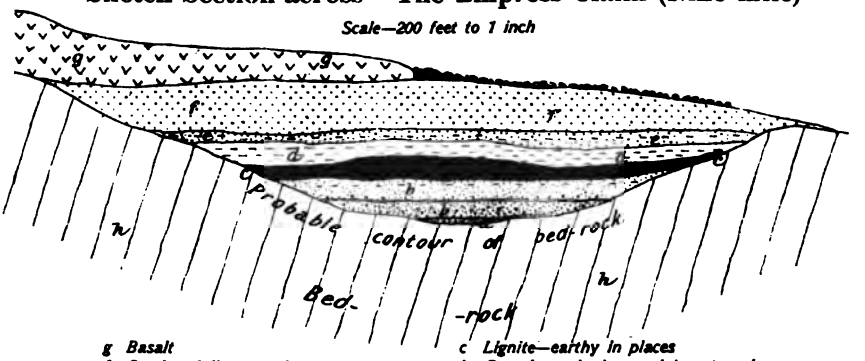
By dumpy level the difference between the Giandarra and Homeward Bound Claims, is 22.750 feet.

There is thus very little fall in the New Chum Hill wash, although large potholes occur in the old river channel.

From the North Bloomfield to the Township Hill Tunnel mouth a fall of 251.440 feet was measured. As the Basalt Claim wash, 2 miles to the south, is very little higher than the entrance to this tunnel (25 or 30 feet),

Sketch Section across The Empress Claim (Nine-mile)

Scale—200 feet to 1 inch

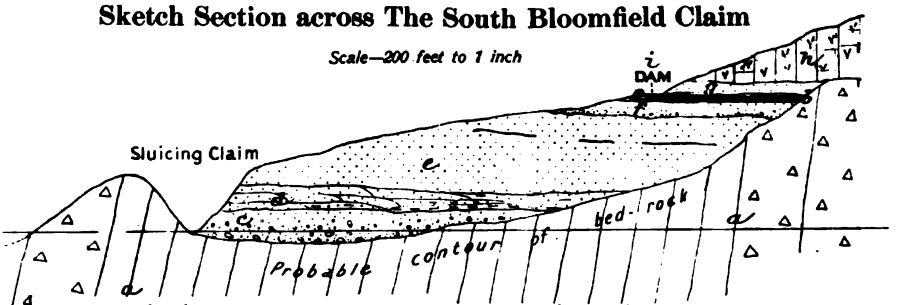


g Basalt
f Sand and fine gravel
e Pipeclay and sand
d Stiff clay
c Lignite—earthy in places
b Gravel, sand, clay, and ironstone layers
a Payable wash
h Tuffs, slates, and quartzites

61375

Sketch Section across The South Bloomfield Claim

Scale—200 feet to 1 inch



h Columnar basalt
g Sand
b Lignite
i Dam in lignite, 145 feet above base of wash
f Sub-angular gravel
e Sand, probably containing lignite layer
d Sand and clay showing current bedding, 30 feet
c Wash and sandy gravel, 25 feet
a Tuffs

61375

The wash is enclosed to the east, north, and west by bed rock (tuffs), rising to a considerable height above it.

To the north-west the tuffs are 175 feet higher than the wash.

Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

the bed of the channel should be fairly flat over a considerable distance to the south, but thence to the North Bloomfield a sharp rise may be expected to occur.

From a consideration of the foregoing it will be seen that from the Twelve to the Nine Mile, a distance of 20 miles, the channel has been proved to be very confined, very rarely exceeding 10 chains in width, and possessing a more or less auriferous wash some 50 yards in width; that it has a meandering course; that the old drift is very similar in geological character throughout, consisting of auriferous wash (of varying value), earthy lignite, sand and clay layers with an uniform thickness of 150 to 170 feet; and that a constantly decreasing level exists between the claims of the Nine and Twelve Miles.

It thus fulfils all the conditions required for it as a river, while the conditions are altogether opposed to those obtaining in a typical lake.

Description of Claims, and Auriferous Contents of the Lead.

(*a.*) The Empress Claim and Neighbourhood.

Very rich waterworn gold was found in Scott's Gully, and by working up this watercourse, the gold was traced into the old drift underlying the basalt.

At this point the lead was found to be exposed in natural section on the hillside.

From the sluicing claim started at this point and named the Empress, considerable quantities of gold have been obtained similar in character to that obtained in Scott's Gully surfacings.

In the sluicing claim the whole of the wash was taken, no distinction being made between the rich auriferous channel and the poorer and higher contiguous wash.

A rough estimate made by Mr. J. M. Lette, (the proprietor) of the ground treated by hydraulic sluicing, together with a larger area adjoining it and treated by surface sluicing amounted to 60,000 yards, yielding £1 per yard.

Certain yields from sluicing operations at the Empress Claim during the years 1884–1889, and supplied by Mr. J. Pattinson, senr., from the Company's books, amount to 3,400 yards, sluiced for a yield of 496¼ oz. gold.

On the suspension of sluicing operations (owing to the difficulty of removing the "overburden" of basalt, &c.) a main tunnel was driven in about 2,000 feet, and from 30 to 33 feet below the lowest wash exposed in the sluicing claim.

An upper tunnel was driven through the wash, keeping as nearly as possible to the centre of the auriferous channel.

Cross drives have been put in on each side of this upper tunnel for about 50 to 75 feet to prove the wash.

"In all about 1,000 feet along the channel are now ready for blocking out, which should yield 12,000 superficial yards of wash averaging 4 dwt. to the yard." (Mr. J. M. Lette, Proprietor.)

Two dishes of dirt taken from the centre of this area, and washed in my presence, yielded about 3½ grains of gold.

In the Nine Mile Creek, wonderful yields of waterworn gold were obtained in the early days of the field, and, as in the case of Scott's Gully, the gold has been traced up the watercourse to a point where it disappears under the basalt.

The amount of gold won in Scott's Gully and Nine Mile Creek cannot even be approximately arrived at, owing to the non-existence of records of gold yields, but from all accounts it was very great.

(*b.*) The South Bloomfield.

This claim (sluicing) never yielded gold to any extent, but it must be remembered that the prospectors have here only touched the wash, and do not appear to have gone nearly deep enough to prove the lowest portions.

This will be evident from a glance at the accompanying sketch section.

Here it will be seen that the excavation is mostly in bed-rock and the channel dips away from the open cut into the hill.

The Four Mile Creek, in the break between the North and South Bloomfields has yielded great quantities of coarse gold, said to be indistinguishable in character from the gold of the lead.

All along the course of this creek, between the limits just mentioned, large angular and subangular fragments of quartzite occur similar to those seen at the Nine Mile and covered partly by the basalt.

It is very probable that these quartzite masses represent conglomerates or the upper wash of the lead, altered to quartzites by the heating action of the basalt, and have remained owing to their hardness, while the softer parts of the wash have been removed after the denudation of the basalt cap, and that the gold present in the creek also represents, in great part, that which was originally contained in the lead, although the bed of the lead was some 200 feet higher than the level of the present stream. .

(*c.*) The North Bloomfield.

This claim like the South Bloomfield was taken up as a sluicing area. A deep tail-race was cut and an excavation made in the hillside some 5 chains long, 1½ to 2 chains in maximum width, and 50 feet deep.

This claim has not produced much gold, but the remarks made concerning the South Bloomfield are applicable here also. It is almost certain that the deepest ground has not been touched. (See diagram .)

At this point and for some distance southwards the lead appears to be confined beneath the basalt and does not show on the side of the hill.

(*d.*) Basalt Claim and Tunnel.

These claims occur on a steep spur of Township Hill overloooking the Eucumbene River near its confluence with the Four Mile Creek.

Basalt Claim was taken up as a sluicing area. Very little work was done and the returns were poor. The hill, at this point, cannot be said to have been properly tested.

The diagram represents a sketch section based on measurements obtained at this claim.

Basalt Tunnel is a little more than 40 chains north of the latter claim, and consists of a tunnel driven some 300 or 400 ft. into the hill beneath the basalt. Well rounded quartz wash was obtained from the tunnel. The channel was auriferous, but was never properly tested.

The wash, lignite, and sand amount to fully 120 feet as determined by aneroid readings.

A section through this claim would be very similar to those obtained at the North and South Bloomfields.

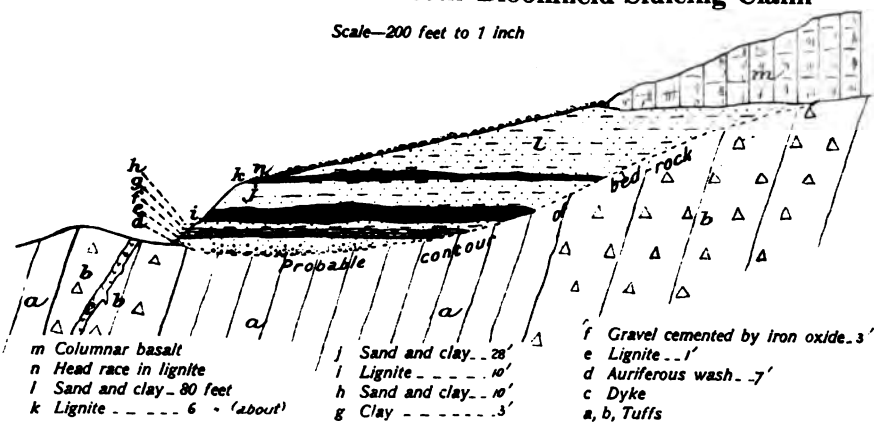
Gold was obtained in the small gully leading from the tunnel to the Eucumbene River.

(*e*) The northern portion of Township Hill.

In Pollock's Gully, at the township of Kiandra itself, wonderful gold yields were obtained. The gold was said to be partly waterworn and partly ragged, like that found in the lead itself.

Sketch Section across The North Bloomfield Sluicing Claim

Scale—200 feet to 1 inch



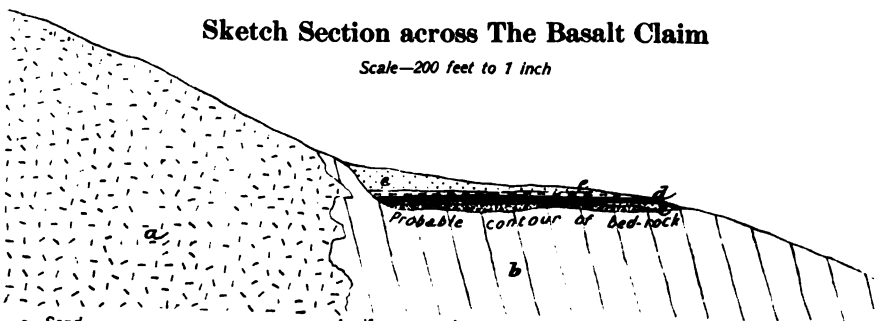
m Columnar basalt
n Head race in lignite
l Sand and clay_ 80 feet
k Lignite _ _ _ _ 6 " (about)
j Sand and clay_ _ 28'
i Lignite _ _ _ _ _ 10'
h Sand and clay_ _ 10'
g Clay _ _ _ _ _ _ 3'
f Gravel cemented by iron oxide_ 3'
e Lignite _ _ 1'
d Auriferous wash_ 7'
c Dyke
a, b, Tuffs

01375

The slope of the working face is shown in the sketch, and the lowest part of the auriferous wash has evidently not been exposed.

Sketch Section across The Basalt Claim

Scale—200 feet to 1 inch



e Sand
d Clay, Lignite, and sand
c Auriferous wash
b Tuffs
a Quartz felspar porphyry

Forty chains to the north, the river gravel and lignite are together 120 feet thick, overlaid by basalt.

01375

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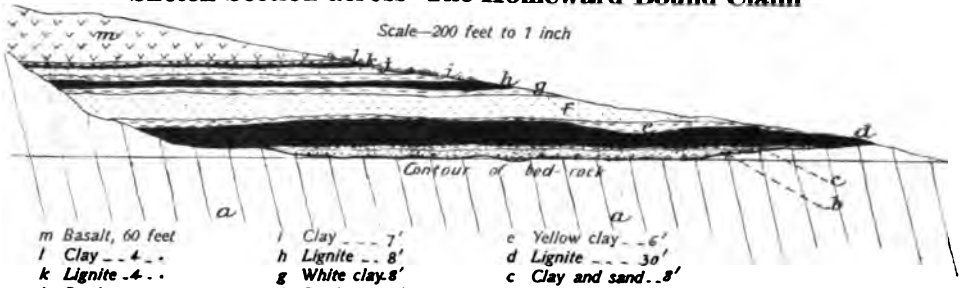
Sydney, N.S.W.

HOMEWARD BOUND OPEN CUT.

Sketch Section across The Homeward Bound Claim

Scale—200 feet to 1 inch



m Basalt, 60 feet
l Clay ... 4'
k Lignite ... 4'
j Sand ... 11'
i Clay ... 7'
h Lignite ... 8'
g White clay 8'
f Sand ... 30'
e Yellow clay ... 6'
d Lignite ... 30'
c Clay and sand ... 8'
b Auriferous wash (well-rounded pebbles), 12 feet
a Tuffaceous rocks

61375

Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

The rich prospects ceased in the vicinity of Wesselman's Tunnel, the upper part of the gully not containing payable gold. Although lignite and clay outcrop on the hillside much farther up the gully, it is almost certain that the lower part of the wash was never here exposed on the hillside, since bed-rock occurs to the immediate east at a height of 100 feet above the channel.

At Wesselman's Tunnel, a small break occurs in the bed-rock, and it is probable that the lead was drained of a portion of its upper contents in this locality. Bed-rock, even here, is considerably higher than the base of the wash.

This tunnel appears to be in a good position to prove the lead, and should reach it if carried on for a further distance of 300 or 400 feet.

At the north-east point of Township Hill the course of the old channel (or, at least, one of its branches) is seen. Here 100 feet of river wash, carbonaceous clay, and sand are exposed in natural section. (Plate VI.)

A small gully leads thence to the Eucumbene River, known as Whipstick. Very rich coarse waterworn and ragged gold has been traced along the whole course of the creek, to the spot where it ends in the wash of the lead.

Township Hill Tunnel was driven in here to prove the auriferous character of the wash. The lowest portion of the channel was not reached; enough was, however, tested of the drift to prove its goldbearing character.

(*f*) Homeward Bound, Cornishmen's, and Pattinson & Winckler's Claims.

These claims have been worked both by hydraulic sluicing and tunnelling.

Hydraulic sluicing has, in all cases, had to be dispensed with, owing to the great amount of "overburden" to be removed.

The Homeward Bound.—Surface sluicing was at first adopted. A tail-race was cut, and the edge of the lead sluiced away. A pothole was worked for years. (Pl. IV.)

The amount of gold won by hydraulic sluicing is shown by the Company's books to have been as follows:—6 acres of ground (about 29,000 yards) were treated for a yield of 5,353 oz. 8 dwt. 11 grs. Half of this had, however, been blocked out previously, and that along the richest ground, so that the above results do not represent the amount originally contained in the lead.

The Cornishmen's Claim.—This adjoins the Homeward Bound property, and is plainly a western extension of the lead exposed in the Homeward Bound workings.

As in the latter claim, the best part of the wash was blocked out previously to the introduction of hydraulic methods.

Between 3 and 4 acres were sluiced for a yield of 1,024 oz. 11 dwt. 6 grs. of gold.

Pattinson and Winckler's Claim.—As in the Homeward Bound and Cornishmen's Claims, a mass of wash, 150 feet thick, is here exposed by hydraulic sluicing (Plate V).

Tunnelling in this area has been resorted to by as many as three or four different parties. Of 8,200 superficial yards sluiced only 2,100 were solid ground. The yield from three was 587 oz. 7 dwt. 16 grs., the equivalent of £2,197 9s. 10d.

All the above yields have been taken from the various Companies' books.

From these New Chum Hill Sluicing Claims, Mr. W. H. J. Slee mentions the following returns:—

16,955 tons sluiced, for 926 oz. in 1884.
7,075 yds. „ 1,060 „ 1885.*

* Ann. Rep. Dept. Mines for 1885, p. 107

(*g*) Robyn's Tunnel, The Giandarra, &c.

New Chum Hill has also been proved to the north by the claims known as Robyn's Tunnel, The Giandarra, Luttrell's Sluicing Claim, and the All Nations' Claim.

Robyn's Tunnel is about 787 feet in length, driven in a direction a little south of west. After driving 330 feet through altered slates, a small rise was put up and the wash reached. The surface bed of the bed rock was, however, dipping into the hill, and the lignite was inclined at an angle of 20 degrees or more.

Further driving and cross-cutting revealed the presence of a very uneven bottom to the channel. The basal rock at first rose, but afterwards sank below the floor of the tunnel.

Five hundred feet in, the wash dips below the floor, and is in this condition to the end of the tunnel.

The wash is very interesting in the Giandarra, being of decidedly black nature, owing to the colouring of the fine-grained sand between the pebbles.

Large quartz-boulders occur, some as much as 5 feet in diameter. Much of the wash is also only partly rounded.

Above the black wash a layer of iron pyrites occurs, varying from 1 to 6 inches in thickness, and on this a very soft, black, fine-grained carbonaceous clay is superimposed.

The section illustrates the confining of the channel, its uneven bed, the irregular disposition of the lignite, and the unfortunate position of the tunnel for winning the gold in the end of the workings.

The gold yields from the Giandarra, as supplied by Mr. Hetherington, of Kiandra, are as follows:—

1,000 yards extracted for a value of 11s. 6d. per yard.
The first 290 yards blocked out yielded 40 oz.*

(*h*) The Six Mile.

At the Six Mile Creek workings very rich yields were obtained from the shallow ground. The gold, on being followed up the creek, was traced into the lead. This latter has not been at all thoroughly prospected. A small portion of it has been sluiced. Lately a tunnel has been driven in some 500 feet to intercept the wash. The work of driving is still progressing, but the channel has not yet been reached.

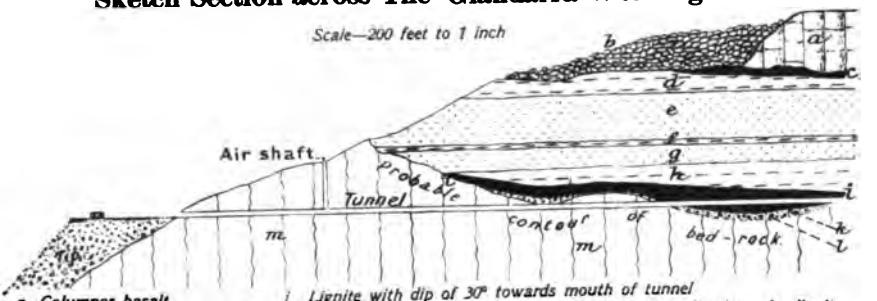
THE KIANDRA REEFS AND THE ORIGIN OF THE GOLD IN THE LEAD.

No payable auriferous reefs have been discovered in the neighbourhood of Kiandra, although reefs and lenticular patches of quartz exist in great quantity. A few gave good returns from surface crushings, but at very slight depths the gold contents became practically nil. Very rarely are the reefs in the form of true fissure veins. They occur mostly as silicifications, following the strike of the country; in fact, most of the slate country to the west of Kiandra is very altered, and is in places replaced to a remarkable extent by white quartz.

The Three Mile Reef was one that promised well at the start, giving splendid returns from surface crushings, as mentioned in the historical notes on the district. One hundred and twenty feet of outcrop were pegged out,

* W. H. J. Slee, Ann. Rept. Dept. Mines for 1898, p. 95.

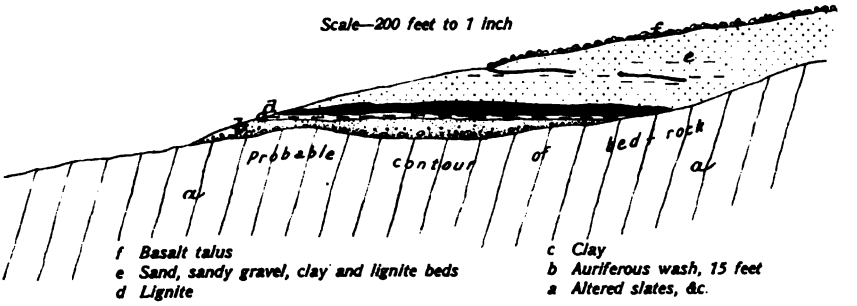
Sketch Section across The Giandarra Workings



a Columnar basalt
b Basalt talus
c Lignite
d, e, f, g, h, Sand and clay
i Lignite with dip of 30° towards mouth of tunnel
k Layer of iron pyrites, 2 to 6 inches thick, immediately under lignite
l Black auriferous wash, 2 to 5 feet thick
m Schistose slates

81078

Sketch Section across The Six-mile Claim



f Basalt talus
e Sand, sandy gravel, clay and lignite beds
d Lignite
c Clay
b Auriferous wash, 15 feet
a Altered slates, &c.

81375

Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

HYDRAULIC SLUICING AT PATTINSON AND WINCKLER'S CLAIM.

and at a little depth the reef was proved over 10 chains of length. The vein was very pronounced, being 3 feet wide, and possessing a westerly dip.

Five hundred tons are said to have been obtained from this reef, with an average value of 15 dwt. to 1 oz. per ton.

The Charcoal Reef occurs in slates, and in the vicinity of a small granite boss, and also of a small patch of norite. The vein is not well pronounced. Good yields are reported from the surface stone. Fifty or 60 tons were crushed for an average of 2 or 3 oz. per ton. For these returns I am indebted to Mr. Eastwood, of Kiandra.

In the tuffs near the township various auriferous reefs occur.

One, in Pollock's Gully, about ½ inch in width, is said to average some 10 dwt. per ton.

At Jackass Flat, in the river bed itself, a quartz vein was worked. From the cap of the reef 3 tons were crushed for a yield of 30 oz. per ton. Eight feet below the surface the gold apparently gave out. (Information supplied by Mr. Eastwood.)

Surface Hill Reef.—This strong reef occurs in the vicinity of the township itself, having a strike in a N.N.W. and S.S.E. direction, and a high angle of dip in a westerly direction.

The outcrop has been traced over a length exceeding 40 chains. It occurs in a thick belt of andesitic tuffs in the neighbourhood of a small norite boss, and is traversed by numerous slickensided faces.

Calcite is somewhat abundant. A large specimen, yielding 28 lb. weight of gold, was found lying immediately to the east of the reef cap. The reef has a poor appearance, and, on being tested, has yielded nothing of value.

Origin of the Reefs.—The country was folded by great granite intrusions (of which there is abundant evidence both to the east and west of Kiandra), and numerous fractures formed in the country rock, which were subsequently filled with quartz. Innumerable lenticular patches of quartz occur also in the slates to the west, which are due partly to the infilling of fractures and partly by secondary silicification setting in along lines of weakness.

There is every reason to believe that these lenticular quartz patches (as also reefs similar to the Three Mile, Jackass Flat, and Surface Hill occurrences) contained varying quantities of gold, and that as the slow process of denudation progressed, these quartz segregations were exposed and removed in turn, while their auriferous contents were carried into the lead.

METHODS OF WORKING THE KIANDRA LEADS.

Canvas hose for surface sluicing was used in the early days of the field. The hills around Kiandra are in places covered with lines of races, which follow the contour of the country for miles.

As the lead was worked farther into the hillsides, and the amount of overburden increased, this method of sluicing ceased to be effective.

The hydraulic system was then introduced. Dams were constructed, which, owing to the elevated position of the lead (about 5,000 feet above sea-level), allowed of rather restricted catchment areas. The excessive rain and snowfall of the district, however, and the little loss suffered by evaporation at this altitude compensate, in great measure, for the lack in area of gathering ground.

In the case of New Chum Hill, the Three Mile was selected as a suitable site for collecting water, a dam was erected, and a large head race was constructed 4 or 5 miles in length, wherewith to convey the water to treat the wash in the Homeward Bound and Cornishmen's Claims.

The catchment area of the Three Mile Dam is about 750 acres; that of Pig Gully about 550 acres. With a rainfall of 64 inches per annum, this would give a total of nearly 2,000,000,000 gallons if all the water falling on the area could be conserved. Probably, however, not more than one-half could be saved.

The Pig Gully Dam is not an accomplished fact, but an excellent site exists for constructing one, a natural retaining wall of slate running across the gully near its mouth, which, at a moderate cost, could be formed into a strong dam.

The head-race was 130 feet above the base of the wash in the Homeward Bound Claim.

With the water power gained by this height the lead was sluiced by nozzles. This method was effective until the overburden reached a thickness of 150 to 170 feet, at which points the wash was heavily capped with basalt. The latter has been found very difficult to cope with in quantity, and one by one, as the basalt became pronounced, the sluicing claims were abandoned, and tunnelling is being resorted to. (Plate V.)

Hitherto the various tunnels driven into the hills have, with one or two exceptions, been chosen in a most haphazard fashion.

The Empress Tunnel is one that was driven some 30 feet below the base of the wash, but in the direction of down, instead of up, stream, so that, sooner or later, it must pierce the wash. Whereas it was started 30 feet below the drift, in the farthest point yet reached it is but 4 ft. 6 in. below the channel.

The method of working adopted here was the driving of the low-level tunnel (mentioned in previous paragraph) for a distance of 2,000 feet, and the putting up of rises at short intervals into the drift. An upper tunnel was driven along the deepest part of the channel, cross drives being put in at short distances on both sides of this level. The wash is extracted by the system known locally as "panelling." Three or 3½ feet depth of wash are blocked out, laths being placed vertically 1 foot apart to support the overlying mass. As the "panelling" progresses, the wash crushes the laths and settles down.

The Giandarra is worked on a similar principle; but in other cases the tunnels have been driven at levels altogether too high to win the wash. These serious blunders arose from a desire not to encounter very hard bed rock in tunnelling.

In a country like Kiandra, possessed of great rain and snowfall, where the columnar basaltic capping allows of ready percolation of surface waters through the interstices between the columns into the underlying drift, it is absolutely essential to have a lower tunnel well below the wash.

Not only must this tunnel be below the general level of the channel, but also below any deep potholes which may reasonably be expected to occur in the bed of the lead. Thus, for instance, a large one, 20 feet deep, occurs in the Homeward Bound, and in modern river beds large holes occur quite 50 feet in depth. These, if not taken into consideration, may be tapped by the lower tunnel, causing imperfect drainage, thereby hindering the work.

From the northern extremity of Township Hill the lead rises towards the North Bloomfield.

It has been suggested to work the wash in Township Hill by carrying a wide low-level tunnel into the hill, and 50 feet below the base of the wash (which, by the way, has not yet been ascertained), to connect the same with an upper tunnel in the wash by means of passes put up at every 50 or 100 feet, to develop as much ground as will give employment to 150 men blocking out, and 70 to 80 truckers, and to utilise the lower level for sluicing purposes.

EXPOSURE OF LEAD IN WHIPSTICK GULLY.

For treating the wash on such an extensive scale, the northern point of the hill would form as convenient a spot as could be chosen at which to commence operations, since at this point the upper part of the lead is exposed in natural section, there is a good get away for the tailings, and the town would suffer no inconvenience.

Similarly, a tunnel driven well below the wash in Pattinson & Winckler's Claim would command the lead in New Chum Hill, for the fall thence to the Giandarra is but 21 feet.

The amount of water which can be conserved in the Three Mile, Pig Gully, and Eight Mile Dams should meet the requirements of the Township and New Chum Hill tunnels.

TOWNSHIP HILL.

Special notice is called to the northern part of this hill, inasmuch as—

(1.) It is the point at which tunnels are proposed to be driven in to work the lead.

(2.) It is not easy to locate the main channel amid such abundant evidences of lignite and wash as occur in this portion of the hill.

The points of occurrence of lignite, clay, and wash may be again enumerated:—

(*a*) Head of Pollock's Gully.

(*b*) North-east point of hill and 15 chains south; also towards Pollock's Gully. (Plate VI.)

(*c*) Jack's Gully, midway between north-east and north-west portions of hill.

(*d*) G. L. 60.

(*e*) Basalt claim and tunnel.

If we dismiss from consideration the wash in the Basalt Claim and tunnel as being tributary to the main lead, though even in these cases the drift is similar to, and but a very few feet above the base of the wash in the main channel, then we have to face the fact that thick masses of drift occur at almost every point on the hillside beneath the basalt, which is from 40 to 50 chains wide at this point.

Three solutions as to the course of the channel may be given:—

(1.) The whole width of the basalt at this extremity of the hill, and for some 80 chains southward, may contain river drift beneath its mass, representing a local broadening of the stream.

(2.) A main channel may exist, represented in direction by the outcropping of lignite at the heads of Whipstick and Pollock's Gullies, and with a great amount of river drift to the east as far as G.L. 60.

(3.) The channel may consist of two loops, one passing through Pollock's Gully and Township Hill tunnel, the other passing through G.L. 60 and Jack's Gully, and effecting a junction with the first near the north-east point of the hill.

There seems to be no doubt as to the existence of an eastern channel, inasmuch as Township Hill tunnel has proved a thick body of river wash, enclosed by a high wall of bed-rock to the east, this bed-rock persisting almost the whole distance to Pollock's Gully, and 100 feet higher than the base of the drift, the presence of river material being again demonstrated at the head of the gully.

The ground, however, at G L. 60 should be prospected well, to form some idea as to the extent of the wash there.

THE ROUND MOUNTAIN LEAD.

Extent.

About 15 miles south-west of Kiandra and near the Round Mountain, wash was discovered under a huge basalt covering. Three miles to the north river drift occurs in great quantity under the basalt, and may be traced for a distance of over 40 chains. The claims of the Phœnix and Golden Crown have been worked here, and are about 700 feet above the Tumut River. A moderate slope from the claims leads to the top of a long ridge stretching north and south for miles. This is composed of basalt, and at the summit is more than 1,000 feet higher than the top of the wash. The basalt, however, is not necessarily 1,000 feet in thickness, but may be of wedge shape in section, owing to the bed rock having an uneven surface, and there is little doubt that originally it was of very great thickness, since the thinnest portion now is over the lead itself. The basalt from this point passes in the direction of the Eight Mile with a break in its continuity where the Tumut Gorge occurs (2,500 feet deep). The basalt caps the gorge on each side and river wash may be picked up under the basalt on each side of the river slopes. At this gap and towards the north the cap is from 2 to 3 miles in width. Abundance of wash occurs at the Eight Mile similar in all respects to that at the Fifteen Mile, and overlain by similar basalt from 100 to 200 feet thick. A great break occurs at this spot in the basalt, the Tumut Ravine, which cuts across its path again, is here over 2,000 feet deep. Some miles to the north-west it is again picked up at New Meragle. Here it has a great superficial extent, but never appears to be more than 100 to 150 feet in thickness. Tunnels driven under it have proved the existence of considerable quantities of earthy lignite, sand, and wash. I am informed by Mr. Thomas, of Lobb's Hole, and Mr. Cook, of Meragle, that this basalt flow can be traced thence for 20 or 25 miles, with an average width of from 1½ to 2 miles, towards the Cherry Tree Hill basalt, near Batlow, under which payable wash is being worked.

By aneroid readings the Fifteen Mile and Eight Mile workings appear to be on nearly the same level, and reach 750 feet below the Empress Claim wash. The lignite and clay at New Meragle are some 900 feet lower again. Cherry Tree Hill and Tumberumba occupy still lower levels.

The course of the old river thus appears to have been from the Round Mountain neighbourhood, through the Fifteen Mile, Golden Crown, Phœnix, Eight Mile, and New Meragle Claims, and thence possibly in the direction of Cherry Tree Hill.

DESCRIPTION OF CLAIMS.

1. Golden Crown and Phœnix.

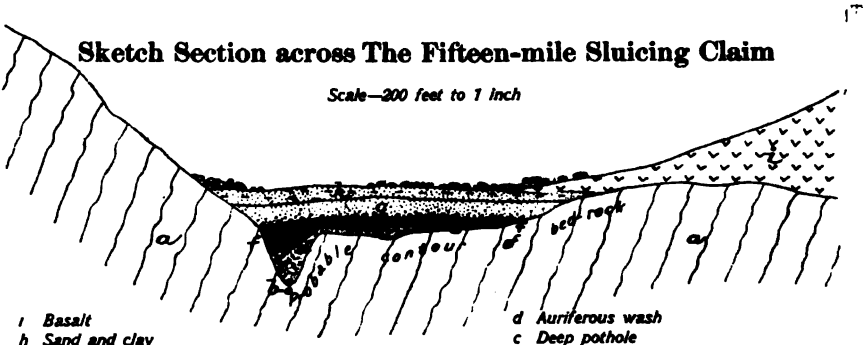
Great bodies of wash have been sluiced away at both these claims. Hydraulic sluicing was employed at the former claim. Mr. J. M. Lette, the proprietor, is preparing to work the properties again by similar methods.

In the Golden Crown a deep V-shaped depression occurs some 100 feet below the general level of the channel bed. This may represent the gutter, but is more likely to prove a very deep pothole. Various tunnels were driven in from the creek running through the property to win the gold contained in the depression. The lowest one was put in about 800 feet to command the wash. This answered very well until the roof fell in, upon which work was abandoned for a while.

The layers of wash, lignite, clay, and sand, are as well marked in both claims as in the Kiandra Lead.

Sketch Section across The Fifteen-mile Sluicing Claim

Scale—200 feet to 1 inch



i Basalt
h Sand and clay
g Non-payable wash
f Lignite and clay in thin bands
e Clay and ironstone layer containing numerous leaf impressions
d Auriferous wash
c Deep pothole
b Lett's lower tunnel
a Contorted schists, quartzites, and slates

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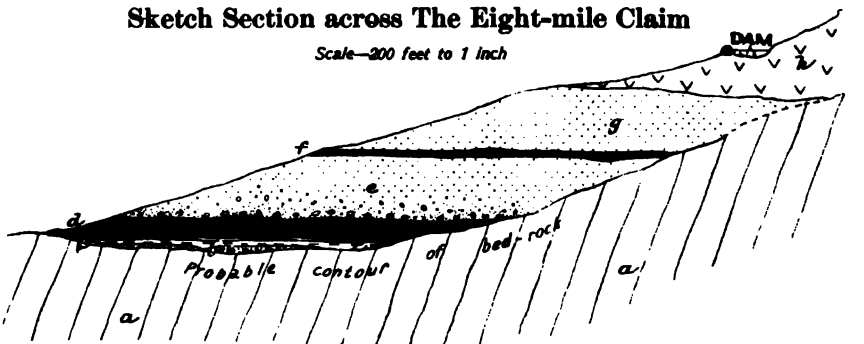
Sketch Section across The Eight-mile Claim

Scale—200 feet to 1 inch



h Basalt
g Sand and sandy gravel, 60 feet
f Thin bed of lignite
e Sand and gravel, 50 to 55 feet
d Lignite with intercalated clay laminæ 20 feet
c Clay and ironstone layer containing leaf impressions, 10 feet
b Auriferous wash, 6 feet.
a Slates, &c.

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Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.

There is a marked difference, however, in their characters, the lignite being harder in the Fifteen Mile, and consisting of very thin layers intercalated with very thin clay seams.

Two beds of auriferous wash occur, one above and one below the lower carbonaceous layer. Both, however, are very poor as compared with the wash found in the New Chum and Empress Claims.

A seam of indurated clay or impure ironstone, 12 inches thick, and occurring between the lowest wash and lignite, has always hampered sluicing operations owing to the difficulty in removing by ordinary means. This seam contains numerous well-preserved specimens of leaves.

The clayey lignite and wash in the depression mentioned before possess most pronounced dips.

The Eight Mile.

Gold was traced up a creek from the Tumut River to the wash in this claim. The section yielded by sluicing operations is very similar to those of the Fifteen Mile Claims, the clayey lignite seam, the "cement" or impure indurated ferruginous clay seam, and the occurrence of poor wash both above and below the lignite, being almost indistinguishable in the two localities.

Great quantities of dirt have been treated by hydraulic sluicing. Trouble was experienced by the continual fall of trees and logs into the claim as sluicing operations made progress, and also by the persistence of the "cement" which proved so troublesome in the sluicing of the Fifteen Mile Claims.

The returns from this claim were not satisfactory.

New Meragle.

Thompson and Howard's Claim is some 3 miles distant from the Tumut River, and 2,200 feet above its junction with the Yarrangobilly River.

A large sheet of basalt has here formed a small tableland. Towards the river the basalt has been cut through by local streams, and on the slope below the local cap river wash consisting of sand and pebbles is seen. Small shafts have been sunk here but without reaching the base of the wash.

Three tunnels have been driven in the side of the hill about 300 yards from the break in the basalt. The upper one was driven into a solid seam of clayey lignite similar to that in the Fifteen and Eight Mile Claims.

A lower tunnel was then put in, but still too high. Another one is being driven 50 feet lower. This has passed through solid gneissic granite for a distance of 300 feet. It is expected that the tunnel will have to be continued for a further 200 feet before reaching the wash. This tunnel is probably low enough to work the wash, unless the lignite seam passed through proves to be the upper layer instead of the one immediately overlying the "cement" and lower wash.

CONCLUSION.

We may summarise as follows:—

(1) Two well-defined leads exist in the Kiandra district, one passing through the Nine Mile, Township, and New Chum Hills, the other by way of Round Mountain, the Fifteen Mile, the Eight Mile, and New Meragle.

(2) Both have a distinct fall from south to north; they are each capped by basalt; the made ground in each case is some 150 feet in thickness, confined between narrow banks, and composed of auriferous wash, carbonaceous clay, sand, and adhesive clay layers.

(3) The auriferous nature of each was suspected by tracing gold up the present watercourses to the basalt cap.
(4) Wherever proved, the channel is more or less auriferous.
(5) The Empress Claim and the northern portion of New Chum Hill are the only places really opened up along the line of the Kiandra Lead. Many thousands of superficial yards have been sluiced away at the New Chum Hill properties, and this after the richest portions of the channel had been blocked out by Drummond and party, Colquhoun and party, and others. The returns, taken from the Companies' books, show a gold yield of 6,965 ounces for a treatment of 52,200 superficial yards.
(6) The auriferous wash is not confined to a narrow gutter, but is distributed over an uneven bed varying from 50 to 100 yards in width.
(7) There is every reason to believe that the wash from Pattinson and Winckler's Claim towards the Giandarra will be very similar to that found in the former claim, as also to that at the Homeward Bound.
(8) Made ground occurs throughout the whole of the north end of Township Hill, and it is proposed to work the wash contained therein by means of a long low-level tunnel driven in at the north-east corner.

The chief difficulties to be encountered in this work will probably consist of the great distribution of river drift over an uneven bottom.

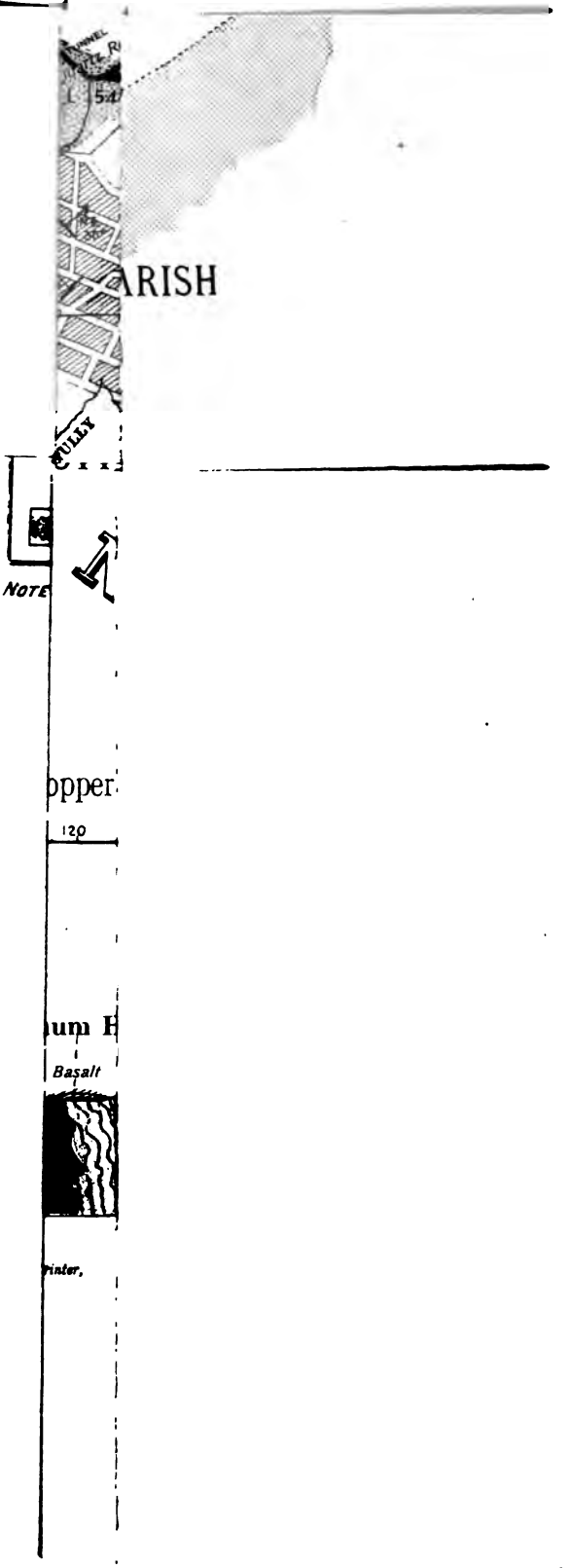
(9) An equally good, if not better, scheme would be to block out the wash from Pattinson and Winckler's Claim towards the Giandarra, the fall in the channel not exceeding 22 feet.

DESCRIPTION OF PLATES.

Frontispiece. New Chum Hill, showing open cuts from the south.

1. Kiandra Bucket Dredge, from Whipstick Flat.
2. Kiandra Township and Eucumbene River from the south.
3. "The Walls," Lobb's Hole.
4. Homeward Bound Open Cut.
5. Hydraulic Sluicing in Pattinson and Winckler's Claim.
6. Exposure of Lead at head of Whipstick Gully.

Sydney: William Applegate Gullick, Government Printer.—1901.


ARISH
GULLY
NOTE
opper
120
Basalt